PREDICTION OF COMMUNITY COLLEGE STUDENTS' SUCCESS IN DEVELOPMENTAL MATH WITH TRADITIONAL CLASSROOM, COMPUTER-BASED ON-CAMPUS AND COMPUTER-BASED AT A DISTANCE INSTRUCTION USING LOCUS OF CONTROL, MATH ANXIETY AND LEARNING STYLE

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The purpose of this study was to investigate the relationship between individual student differences and academic success in three pedagogical methods (traditional classroom, computer-aided instruction (CAI) in an on-campus setting, and CAI in a distance education setting) for developmental mathematics classes at the community college level. Locus of control, math anxiety and learning style were the individual differences examined. Final grade, final exam score and persistence were the indicators of success. The literature review focused on developmental mathematics, pedagogical techniques and variables contributing to academic performance. Two parallel research populations consisted of 135 Beginning Algebra students and 113 Intermediate Algebra students. The Rotter I-E Locus of Control Scale, the Abbreviated Mathematics Anxiety Rating Scale, the 4MAT Learning Type Measure, and an instrument to gather demographic data were used.

It was the conclusion of this study that the instructional methods were not equal with respect to achievement. In Beginning Algebra, the CAI students received significantly higher final grades than did the traditionally taught students. In Intermediate Algebra traditional students scored significantly higher on the final exam than did the

CBI students. There were more students persisting than expected in traditionally taught Beginning Algebra and no significant difference in attrition in Intermediate Algebra.

There was no significant prediction of achievement in Beginning Algebra. For Intermediate Algebra math anxiety was a significant predictor for final exam percentage and locus of control was a significant predictor for final grade percentage. Only the instructional method contributed significantly to the prediction of attrition.

While these findings are statistically significant, they account for only a small part of student success. However, the results had implications for the future. In particular, further study should be given to the question of whether CAI, and its associated expenses, is prudent for developmental mathematics instruction.

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INTRODUCTION

To function in today's job market, students must learn to become good mathematical problem solvers and critical thinkers. They should be confident in their math ability and be able to apply what they know in novel situations as well as to learn new content on their own (Borasi, 1996). The National Research Council (1989) concurs:

> Jobs that contribute to this world economy require workers who . . . are prepared to absorb new ideas, to adapt to change, to cope with ambiguity, to perceive patterns, and to solve unconventional problems. It is these needs, not just the need for calculation (which is now done mostly by machines), that makes mathematics a prerequisite in so many jobs (p. 1).

The American Mathematical Association of Two-Year Colleges (1995) also agrees stating:

> Higher education is situated at the intersection of two major crossroads: A growing societal need exists for a well-educated citizenry and for a workforce adequately prepared in the areas of mathematics, science, engineering, and technology, while, at the same time, increasing numbers of academically underprepared students are seeking entrance to postsecondary education (p. 1).

Since basic mathematical skills are essential in personal as well as in employment arenas, problems in this area have grim social and economic implications. When otherwise capable students avoid the study of mathematics, their career options are limited, diminishing the country's resource base in science and technology (Hembree, 1990).

Deficiencies can occur in any academic area, but students seem especially susceptible to failures in mathematics. Weaknesses elsewhere (such as English or history) which are evidenced in the early grades, are often corrected in successive grades or years. However, mathematics is a different story, since higher levels are built upon the prerequisite skills and the cognitive preparation of preceding classes. Therefore, problems in mathematics are frequently compounded as the student attempts to catch up (Clawson, 1991). Kogleman and Warren (1978) stated that "negative math experiences most often frequently occur between the seventh and tenth grades" (p. 16).

Problems in mathematics begun at the pre-collegiate level continue into the higher education setting. Remedial college-level mathematics courses are required by many college students. In 1985, remedial math courses in public four-year colleges represented about one quarter of all math courses taught in those institutions (Dusewicz, 1985). In a survey done by the Conference Board of Mathematical Sciences (Albers, Loftsgaarden, Rung & Watkins, 1992) it was shown that 56% of students studying mathematics in two-year colleges were studying at the remedial level. The percentage of entry-level college students taking remedial and precalculus mathematics courses increased by 33 percent between 1970 and 1990 in four year colleges and universities, and by 198 percent in two-year colleges (Alberts, Loftsgaarden, Rung & Watkins in Academic Systems, Inc., 1996). Community colleges across the nation report that the majority of their students need mathematics remediation. The president of a community college in Florida reported that between 50 and 70 percent of incoming freshmen require remediation in algebra (King & Crouse, 1998).

Calls for mathematics reform have echoed across the United States for the past 45 years. Because of the needs of the job market for mathematically competent workers, the dissatisfaction with the current state of school mathematics instruction is growing. The media has given considerable attention to problems cited in mathematics education research (Borasi, 1996). Professional mathematics organizations such as the National Council for Teachers of Mathematics (NCTM) and the National Research Council (NRC) have made recommendations for mathematics reform (NCTM, 1989, 1991; NRC, 1989, 1990, 1991b). Early efforts focused on shifts in curriculum (such as the "new math" of the 1960s) and shifts in the perception of learning and the components of teaching (Borasi, 1996). More recent recommendations focus on the development of important mathematical skills listed by Borsasi (1996) as "the ability to pose and solve a variety of math-related problems, to reason and communicate mathematically, and to appreciate the value and potential applications of mathematics" (p. 2).

Community colleges attempt to meet the mathematics instructional needs of a student body diverse in both ability and background with a variety of offerings. Learner and institutional instructional options have expanded as technology permits pedagogical efforts to take previously undreamed of avenues. Traditional classroom instruction, with both the instructor and the student physically present, is both popular and effective. Technology has made possible a modification of this traditional classroom using the computer and specialized software to teach the curriculum. In addition, the changing needs and lifestyles of learners have supported the development and use of distance education and technology-based alternatives, free from the constraints of time and place. The unprecedented growth of the Internet, both in the work place and at home, provides enormous opportunity for, and has placed pressure on, education to adopt and adapt to this new technology and thus alter the delivery of education.

Rationale

Some students select a certain section or teaching methodology of developmental mathematics because of scheduling or geographic constraints. Others, however, have a choice of which format of classes they take. Presently, there is no research-based guidance for students or institutions as to which form of class could provide students with the best opportunities for success.

Predicting the success of individual students in any learning situation is an intricate task seldom achieved with complete accuracy because of a plethora of intervening variables. Although the task seems daunting, a model which identifies individual student characteristics that tend to maximize the opportunities for academic success through appropriate selection of instructional methodology would be very useful. Identification of the characteristics that typify students with successful academic achievement in each modality, if these characteristics differ by modality, could allow guidance counselors to encourage students to enroll in the type of instruction best suited to each individual. However, the President of North Lake College stated that the Dallas Community College District had not conducted any significant research to address this possibility (D. England, personal communication, August 10, 1998), nor has a review of literature disclosed such research elsewhere.

Other researchers have confirmed the need for an instrument predicting student success in various learning environments. Although Wetle (1997) found the Telecourse Self-Assessment Predictor Inventory did not predict student telecourse success, the results of her study supported a premise that a prediction instrument would be valuable in assessing student needs and predicting the at-risk population in the distance learning environment. While a method of predicting success would be valuable for any pedagogical methodology, it would be especially valuable when the student population is at risk, as are the developmental mathematics students in the community college setting.

Theoretical Foundations

The theoretical foundations of the prediction of academic achievement, and in particular the affective factors of locus of control, mathematics anxiety and learning style as they effect achievement and retention in developmental mathematics, were examined in this study. It was hoped that because the research efforts were based on valid theory, the results of the research could be helpful in understanding the relationships between the factors in the study.

Because the factors that effect academic achievement are so complex, a model is useful to simplify, define and categorize them. This research used a model proposed by Dr. Benjamin Bloom (1976), a well-known researcher in the field of educational learning, to examine the factors which effect achievement in developmental mathematics. Bloom found that research had demonstrated that when learning conditions are unfavorable for learners they become more dissimilar in learning ability, rate of learning and motivation for further learning. He gathered and performed research focused on the individual learner and found that IQ and cognitive entry skills account for approximately 50% of a student's course grade. Affective student characteristics make up approximately 25% of the course grade and quality of instruction accounts for the remaining approximate 25%. Excluded from his theory were factors not specifically centered on the student, such as school organization, administration, finance, and teacher training.

Rotter's (1966) theory of locus of control was the theoretical foundation in the examination of affective factors that may effect student performance. Locus of control is a measure of the perceived relationship between actions and outcomes (White, 1990). Theoretically, social learning theory was the background for the conception of the locus of control construct. Social learning theory postulates that reinforcements strengthen expectancies that the same reinforcement will follow the same behavior or event in the future. If the reinforcement does not occur in the future, the expectancy is lessened. The logic is that when reinforcement (or outcome) is not perceived as being dependent on one's own behavior, expectancy will not increase as much as if the outcome is seen as being contingent on behavior (Rotter, 1966).

Mathematics anxiety was another affective factor examined in this study. Many researchers (Tobias, 1979; Arem, 1993; Richardson and Suinn, 1972; Smith & Smith, 1998; Green, 1990; Betz, 1978) have studied and verified the existence of mathematics anxiety and its effects on learning. In a review of empirical literature related to anxiety and college students, Head and Lindsey (cited in Risko, Fairbanks and Alvarez, 1991) found that a high anxiety level impedes performance, at least for poor and average students. These findings support the theory that math anxiety effects achievement for developmental mathematics students, especially since their past learning history in mathematics has not been strong.

Accounting for individual differences in learning is not a new philosophy. History records that in 334 BC Aristotle said that "each child possessed specific talents and skills and discussed the concept of individual differences in young children" (Reiff, 1992, p. 7). Learning styles are an explanation of the way people learn and was be included as another affective factor in this study. Learning styles are defined and classified in many different ways (Hickcox, 1995; R. Dunn & K. Dunn, 1975 & 1993; Kolb, 1984). Consistent among these classificatory schemes is the idea that learning style effects the way students learn, how teachers teach and how the two interact. The Learning Type Measure (LTM) (McCarthy & St. Germain, 1998b) which was used in this research as the learning style measurement is based upon the work of Carl G. Jung, David A. Kolb, Kurt Lewin, Isabel B. Myers, Joseph E. Bogen and Bernice McCarthy.

> Specifically reflected in the LTM are (1) situational adaptations of Jung's constructs of feeling, thinking, sensing, intuition, extroversion and introversion. (2) behaviors modeled after Kolb's constructs of concrete experiential, reflective, abstract and active learners, (3) representations of hemisphericity drawn from Bogen, and (4) McCarthy's field work (McCarthy & Germain, 1998b, p. 8-9).

Hemisphericity refers to the different functioning of the right and left sides of the brain. Speech functioning has been shown to reside in the left side of the brain, while spatial capability resides in the right side. In addition, the left brain does lineal, sequential processing while the right brain uses a more global process where "data is perceived, absorbed and processes even while it is in the process of changing" (McCarthy, 1980, p. 71). While the study of brain hemisphericity is fascinating, it was decided that its inclusion in this study would make the design and results overly complex.

For this reason, this study did not use the portion of the LTM that measures hemisphericity.

A detailed overview of the theoretical framework important to this study is discussed in Chapter 2.

Purpose of the Study

The purpose of this study was to investigate the relationship between individual student differences and academic success (as measured by final exam grade, final course grade and attrition) in three pedagogical methods (traditional classroom, computer-aided in an on-campus setting, and computer-aided in a distance education setting) for developmental mathematics classes at the community college level. Locus of control, math anxiety and learning style were the specific individual differences that were examined in this study.

A secondary purpose was exploratory and examines whether other student characteristics (such as age, ethnicity, gender, previous mathematics courses, previous attempts, and employment status) individually or in combination with each other predicted the academic success of individual students in these different instructional methods of developmental mathematics. Previous research (Betz, 1978; Branum, 1990; Cordell, 1991; Parker, 1994; Zaslavsky, 1996) suggested that there may be relationships between these factors and student achievement, although the findings are mixed and there are no clear patterns.

While the research intent was to add to scholarly knowledge, there was also a more practical side to this study. There were only "seat-of-the-pants" methods of advising students about which instructional method might provide the best chance for their success in a class. It was hoped that the results of this research could provide a tool to increase the potential for success for students and those who advise them. Although the results of this study were confined to developmental mathematics in community colleges, it could be expanded for many other types of classes where differing instructional formats are used.

Statement of the Problem

What is the predictive value of mathematics anxiety, locus of control and learning style in estimating mathematics achievement for community college developmental mathematics students enrolled in traditional lecture classes, computer-based instruction in an on-campus setting, and computer-based at a distance classes?

Research Questions

For both the Beginning and Intermediate Algebra groups, the specific research questions addressed by this study were:

1. Are there differences in achievement as measured by final grade (on a scale from 0 - 100%) between developmental mathematics classes taught in the traditional format, the computer-aided in the classroom format, and the computer-aided at a distance format?

2. Are there differences in achievement as measured by final exam score between developmental mathematics classes taught in the traditional format, the computer-based in the classroom format, and the computer-based at a distance format?

3. Are there differences in attrition (persisted vs. dropped out) between developmental mathematics classes taught in the traditional format, the computer aided in the classroom format, and the computer-aided at a distance format?

4. Can achievement, as measured by final grade (on a scale from 0 - 100%) be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

5. Can achievement, as measured by final exam score be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

6. Can attrition (persisted vs. dropped out) be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

7. Are age, ethnicity, gender, previous mathematics courses, previous attempts and employment status related to final exam grade, final grade (on a scale from 0 - 100%) and attrition?

Significance of the Study

This study was needed to synthesize past literature on factors predicting student success and to apply it in the identification of student characteristics which could help to predict success in different modalities of developmental mathematics classes at the community college level.

Basic Assumptions

This study assumed that affective factors influence student academic achievement. This assumption was based on Bloom's (1976) theory of factors that effect student performance. In addition, for the purpose of this study, the assumption was also made that the terms computer-based instruction, computer-aided instruction, computer-assisted instruction, computer-based education, computer-assisted learning, and technology mediated instruction were synonymous. The review of literature (Academic Systems, Inc., 1997; Alessi & Trollip, 1991; Dinkheller, Gaffney and Vockell, 1989; Taylor, 1980) showed that numerous terms were used for instructional computer programs.

Limitations of the Study

This study was restricted by the following factors not under the control of the researcher:

1. All factors in this study were in the form of self-reported information.
2. No student was required to participate.
3. No instructor could be required to participate.
4. Random selection of subjects for the study was not possible. Intact class groups were used for examination of instructional modalities.
5. Measurement of locus of control was restricted to those items on the Rotter's (1966) Internal-External Locus of Control Scale.
6. Measurement of mathematics anxiety was restricted to those items on the Abbreviated Mathematics Anxiety Rating Scale (Alexander & Martray, 1989).
7. Measurement of learning style was restricted to those items on the 4MAT Learning Type Measure (McCarthy & St. Germain, 1998a).

Delimitations of the Study

This study was restricted by the following factors controlled by the researcher:

1. The research sample was drawn from a single community college within the State of Texas.

2. The participation was limited to those students enrolled in developmental mathematics classes. Two levels of developmental mathematics (DMAT 091 Elementary Algebra and DMAT 093 Intermediate Algebra) classes were included in the study and analyzed separately.

3. The study was conducted only during the spring term of 1999.

4. The study was limited to the investigation of the ways in which the affective factors of locus of control, mathematics anxiety and learning style effect achievement and attrition in developmental mathematics. No intelligence testing was given or examined.

5. The study was limited to three pedagogical methods for developmental mathematics: the traditional classroom; on-campus computer-based instruction; and computer-based instruction at a distance.

Definition of Terms

Computer-based instruction (CBI): Courseware that presents all or part of the instruction including presenting information, guiding the student, practicing by the student, and assessing student learning (Alessi & Trollip, 1991).

Developmental mathematics: Mathematics courses at the college level that offer a review of mathematical skills and are prerequisites to freshman level mathematics courses.

Distance education: A teaching-learning arrangement in which the learner and teacher are normally separated by time and distance.

Electronic mail: Electronic transmission, distribution and delivery of a message. The message is stored at an electronic address until the recipient retrieves it via a personal computer equipped with telecommunication hardware and software.

Learning style: Factors that affect a student's ability to practice, internalize and retain new information. The 4MAT concept of learning style used in this study is a four-quadrant model that explains how people perceive and process reality. According to McCarthy (1991) those who perceive in a sensing/feeling way perceive through their senses and immerse themselves directly. Those who think through experiences analyze what is happening and make abstractions. Some people watch first while others do first. Watchers reflect on reality, relating what is happening to their own experiences and choosing their perspectives on the new event. Doers tend to act immediately on new information and try things out before they reflect.

Locus of control: A measure of perceived relationship between actions and outcomes (White, 1990).

Hemisphericity: The different functioning of the right and left sides of the brain. The left brain does lineal, sequential processing while the right side uses a more global process where "data is perceived, absorbed and processes even while it is in the process of changing" (McCarthy, 1980, p. 71).

Mathematics anxiety: "Feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide array of ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551).

Technology-mediated instruction: A type of comprehensive computer-based instruction that includes real-time assessment, individualized learning management, and mathematics tools that are added to the traditional core instructional elements of faculty and text book (Academic Systems, Inc., 1997).

Traditional classroom: Instruction tied to specified times and places, usually including lecture and printed text as the main instructional elements.

Chapter Summary

This study attempted to provide colleges with information that could help identify student characteristics that were predictive of success in different instructional methodologies for developmental mathematics. This was accomplished by examining the affective characteristics of locus of control, mathematics anxiety and learning styles and their individual and combined effect on attrition and academic achievement in the traditional classroom, computer-based instruction on-campus, and computer-based instruction in distance education settings.

Chapter One was designed as an overview of this research project. This chapter discussed the purpose of the study, the problem statement and the significance of the study. A short overview of the theoretical framework was provided and the research questions were defined. In addition, assumptions, limitations and delimitations as well as the definition of terms used in the study were presented.

Chapter Two contains a review of literature describing both the history and current status of research involved in developmental mathematics and its pedagogical methods and factors affecting academic achievement. Chapter Three describes the research population along with the research design, survey instrumentation, data collection and data analysis for the research methodology.

Following data collection, the data was statistically analyzed. Chapter Four contains the data analysis and an in-depth discussion of the results of the study. Chapter Five contains a summary of the findings along with conclusions and recommendations based on the findings.

CHAPTER 2

REVIEW OF RELATED LITERATURE

Introduction

The review of literature centers around developmental mathematics and the possible predictors of success for developmental mathematics students in different instructional settings in the community college environment. The factors examined include developmental mathematics and the methods of instruction used in developmental mathematics including traditional classroom, computer-based instruction (CBI) and distance education methods. The last portion of the review of literature is organized according to a framework devised by Bloom (1976) and examines the complex area of variables contributing to academic performance. The factors examined in this section include cognitive entry skills and intelligence, affective characteristics (including math anxiety, locus of control, and learning styles), and quality of instruction.

The following types of literature were reviewed: (a) dissertation abstracts, (b) entire dissertations, (c) Educational Resources Information Clearinghouse (ERIC), (d) refereed and non-refereed journals, (e) books, (f) state and federal government publications, (e) Internet, (f) computer aided instruction training materials, (g) periodicals, and (h) personal communications.

Developmental Mathematics

The need for effective developmental mathematics instruction is great, although discouraging. In 1985, remedial math courses in public four-year colleges represented about one quarter of all math courses taught in such institutions (Dusewicz, 1985). The percentage of entry-level college students taking remedial and precalculus mathematics courses increased by 33 percent between 1970 and 1990 in four year colleges and universities, and by 198 percent in two-year colleges (Alberts, Loftsgaarden, Rung & Watkins in Academic Systems, Inc., 1996). Community colleges across the nation report that the majority of their students need mathematics remediation. The president of a community college in Florida reports that between 50 and 70 percent of incoming freshmen require remediation in algebra (King & Crouse, 1998).

In 1987 the Texas Academic Skills Program (TASP) was established under section 51.306 of the Texas Education Code. This legislation was designed to ensure that all students attending public universities and colleges in the state of Texas have mastered basic reading, writing and mathematics skills, and requires that all students entering public colleges and universities must be assessed in these areas. Proficiency in these areas can be proven with sufficient ACT or SAT scores (taken within the last five years), or sufficient high school exit level TAAS (Texas Assessment of Academic Skills) scores. If the requirements are not met through the above-mentioned methods, the student must take the TASP or a substitute approved by the state Coordinating Board prior to enrolling in college. If a student does not demonstrate proficiency on one or more sections of the TASP, that student must undergo continuous remediation in developmental classes until mastery is demonstrated and the TASP is passed. As of the fall of 1998, students must begin necessary remediation during the first semester of their college work (Texas Community College Teachers Association, 1997).

Developmental mathematics courses offer a review of mathematical skills and are prerequisites to freshman level mathematics courses if the student is shown to be deficient in mathematical skills. In the Dallas County Community College District, it is common for students to take the same Developmental Mathematics course two to five times before successfully completing it (L. Johnson, personal communication, September 12, 1998). These repeating students can cause enrollments in entry-level classes to double or triple, and the costs for this are not only borne by the repeating student, but also by the campus and the funding agency (Gifford, 1996). The problem is made all the more serious in Texas with new legislation stating that universities will not receive state funding for developmental coursework exceeding 18 credit hours; community and technical colleges will not receive funding for developmental courses in excess of 27 hours (Texas Community College Teachers Association, 1997).

Students who require remediation in math do not fit into a single profile. Some are straight out of high school, but failed to either attain or retain enough mathematical knowledge to be placed into a college mathematics class. Some developmental mathematics students need a refresher course because they have been out of school for several years. Other students never intended to go to college, so they have never taken the necessary preparatory mathematics courses (King & Crouse, 1998). Success rates for developmental mathematics students are affected by a number of factors including the time lapse since the last math class and number of attempts at passing developmental mathematics (Beck, 1996).

Remedial students tend to have problems succeeding in the college setting. In a study examining 2011 Texas public college students, Ainsworth (1996) found that academic success and persistence were substantially lower for all measures and for all ethnic and gender categories for remedial students. It was found that the mean grade point averages were less than 2.00 for all remedial groups. In a qualitative study of students who had succeeded in developmental mathematics, Duranczyk (1997) found that students who experienced success were those with internal motivation. Unanswered is the question of whether affective factors can serve to predict the instructional modality that is most appropriate for the individual student.

Mathematics is often seen as a gatekeeper that serves to filter students out of careers they might pursue if they had the needed mathematics skills (National Research Council, 1989). More than forty percent of mathematics courses offered in the community college setting fall into the remedial category (Chang, 1993), and fewer than half of developmental mathematics students pass developmental math class on their first attempt (Hackett, 1985). The evidence points to a need for research to determine how to maximize the student's potential for success in developmental mathematics.

Pedagogical Techniques in Developmental Mathematics

The professional mathematics community, at both the pre-collegiate and collegiate levels, has long recognized and addressed the need for effectual mathematics instruction (American Mathematical Association of Two-Year Colleges, 1992, 1993 & 1995; National Research Council, 1989, 1990a, 1990b, 1990c, & 1991). The three pedagogical techniques that were examined in this research are the traditional classroom methodology, computer-based instruction in an on-campus setting, and computer-based instruction in a distance education setting.

Traditional Instruction

The agrarian calendar and factory method of bringing students to the institution and working with them in large groups is still the most common form of instruction. In the traditional classroom, students receive a standardized curriculum in a prescribed amount of time. All students, regardless of mathematical background, motivation or any other factors, are placed into a classroom where the pace and depth of the instruction is set by the instructor. Because there is, in most cases, a single instructor, it is difficult if not impossible to structure the instruction to meet the individual needs of each student's learning and achievement. In this model, student needs are often secondary or tertiary to the convenience of educators and the interests of the institution (King & Crouse, 1998). Instruction is tied to specified times and places, and usually includes lecture and printed text. Borasi (1996) describes current mathematics teaching practices as predictable:

> Whether the topic addressed is fractions, geometry, graphing, probability, or even calculus, the lesson is likely to develop as a sequence of review of homework, presentation of new material by the teacher, practice exercises done individually by the students, and assignment of similar exercises for homework (p. 16).

In a 1978 study of mathematics instruction in the United States supported by the National Science Foundation, Welch described the existing mathematics instruction of the day, which could fit most of today's traditionally taught mathematics classes as well:

> In all math classes that I visited, the sequence of activities was the same. First, answers were given for the previous day's assignment. The more difficult

> problems were worked by the teacher or the students at the chalkboard. A brief explanation, sometimes none at all, was given of the new material, and the problems assigned for the next day. The remainder of the class was devoted to working on homework while the teacher moved around the room answering questions. The most noticeable thing about math classes was the repetition of this routine (p. 6, as cited in National Council of Teachers of Mathematics, 1991).

Davis (1996) proposed that traditional mathematics is embodied in rigidly structured curricula, prescriptive teaching methods, and fill-in-the-blank exercises. These activities contribute "to a parsing of the subject matter into singular, sequential, unambiguous, inert and obvious tidbits" (p. xxi). The role of the teacher in such a classroom is that of the overseer, planner and supervisor, resulting in the separation of the educator from learner. The typical college remedial mathematics course presents the student with the same format for learning mathematics as they experienced in high school (Graves, 1998). Why should these students, who had difficulties achieving success under the same conditions in high school, be expected to perform any better in the college setting? Gifford (1996) contends that the difficulty with the traditional model is that it does not account for the impact of student diversity, the amount of prior knowledge a student brings to the class, individual communication preferences, or different rates of learning among students. An argument could also be made that prior experience of failure would condition the student to expect failure in the traditional setting regardless of other factors, thus suggesting the usefulness of a new method of instruction.

However, the traditional classroom also offers a human component that automated, technology-based teaching methods can lack. When an instructor is effective in instruction, establishes a supportive learning climate, and institutes a good rapport with the students, excellent results can be achieved. If these factors, or internal motivation, have been missing in a developmental mathematics student's high school mathematics education, it seems reasonable that the student's performance in a traditional college-level developmental mathematics could improve.

In summary, traditional classroom instruction in mathematics is the most common methodology. Although there are many difficulties in meeting the needs of mathematics students in a traditional classroom setting, in some cases high student achievement can result. When examining methods of instruction or when predicting student achievement in various instructional methodologies, it is important to include traditionally taught classes as a baseline or control group.

Computer-Based Instruction

It has been over 40 years since educators and computer scientists first used computers for instructional purposes. In the 1960's and most of the 1970's, computer-based instruction took place on large mainframe or medium sized computers. Computing in general, including instructional computing, took place at large universities and consisted mostly of typing. Since that time, phenomenal advances have been made in the power and availability of computer technology (Alessi & Trollip, 1991).

The microcomputer was invented in the late 1970's. Since that time there has been a rapid spread of computers in business, personal and educational settings. Early microcomputers were dependent on typing and low quality screen displays. Today, multimedia computers and software allow interaction with the computer through text, voice and other sounds, graphics and pointing with various devices. Many microcomputers are networked together in local areas and these networks are often connected to millions of other computers through use of the Internet.

As technology has improved, computers have become smaller, faster, more powerful and less costly, and their user interfaces have become more intuitive and easier to manipulate. Because of this, many beginning college students own a personal computer, and most students have interacted with the computer though the use of a word processor.

Instructionally, computers are used in various ways. Taylor (1980) divided instructional computing activities into the three categories of tool, tutor and tutee. As a tool, the student uses the computer to accomplish tasks, facilitate academic work and aid in learning. Many students use the computer as a tool as they use a word processor to generate various assignments. As a tutor, the computer delivers instruction. Programs in this category are often called computer-aided instruction (CAI) or computer based instruction (CBI). As a tutee, the student teaches the computer to perform a task. Students who learn computer programming languages use the computer as a tutee, and in so doing learn about the functionality of the programming language. Alessi and Trollip (1991) suggested dividing instructional computing usage into broader categories of administration, teaching about the computer and teaching with the computer.

The computer is not a panacea for instruction. Instead CBI should be used in situations where it is likely to be beneficial. According to Trollip and Alessi (1988), these situations are where: the cost of instruction by other methods is very high (for example the use of flight simulators rather than training on an actual airplane); safety is a concern (such as in a nuclear fission experiment); the material is very hard to teach by other methods (for example graphing in calculus); extensive individual student practice is needed (such as mathematics or foreign language); student motivation is typically lacking (for example, many students are poorly motivated in mathematics); or, there are logistic difficulties in traditional instruction (such as varying the instruction based on individual student progress and results).

Trollip and Alissi (1988) also identified four phases of effective computer-based instruction. These phases are: presenting the information; guiding the students; practicing by the student; and assessing student learning. The computer may serve one or a combination of these four phases. It is important that all four phases be included when the computer is responsible for total instruction.

In mathematics as in other subjects, the amount of time a student spends attending to relevant academic tasks, while performing those tasks with a high rate of success, is likely to relate to academic success. According to Dinkheller, Gaffney and Vockell (1989), when computers enhance learning, they usually do so because they increase academic learning time of individual students. The computer can complete the tiresome part of calculation, allowing the student to focus on applying the results. This ability can reform mathematics education in a shift away from constant practice of isolated procedures and algorithms, beyond human calculation toward a fundamental understanding of when and why to use certain mathematical processes and an exploration of mathematical ideas. In addition, computerized instruction can overcome many of the obstacles encountered in the education of adults. It is individualized, self-paced, and can often be accessed outside of traditional class scheduling.

Since developmental math classes are prerequisite to college-level mathematics courses, their successful completion should lead to success in subsequent, college-level mathematics courses. Baker and Hale (1998) conducted a study to determine whether students taught in a CAI developmental mathematics course did as well as their traditionally-taught peers in subsequent traditionally taught pre-calculus courses. The study was collected over two academic years at the California Polytechnic State University in San Luis Obispo. Through a chi-square analysis, (df 1), $p < 0.01$, they found that a greater percentage of students who took mediated learning algebra courses earned a grade of C or better in Precalculus than their peers.

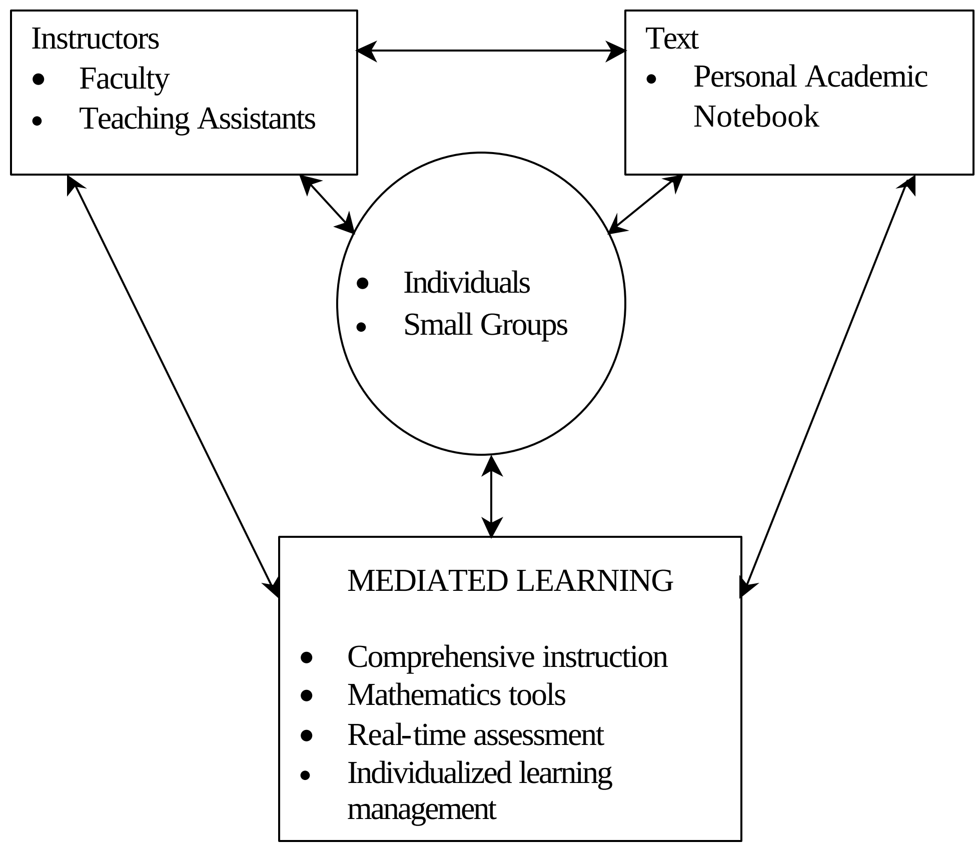
Academic Systems, Inc., a California-based computer based learning company that markets courses to colleges and universities, has coined the term "technology-mediated learning" to describe their CAI software offerings. This model of learning preserves the central elements of the traditional model of instruction, which consists of students, instructor and text. Mediated learning (consisting of comprehensive computer-based instruction, real-time assessment, individualized learning management, mathematics tools and faculty and student support) is added to the traditional core elements (Academic Systems, Inc., 1996e). The model combines traditional instructor-student interaction with a CD-ROM course using audio, video, graphing software and a textbook. Gifford (1996) describes it as:

> . . . learner-centered instruction that is controlled and guided by faculty and made adaptable to each student's individual learning needs that can be significantly more effective, and provide more flexibility for faculty and students, than the traditional lecture-centered model of instruction (p. 1).

Figure 1 illustrates Academic System's view of technology-mediated instruction.

Figure 1

<u>Academic System's Technology-Mediated Instruction Model</u> (1996d, p. 1.)



Students work through a faculty-created syllabus, achieving set goals each week. However, since students have better access to a variety of learning resources via the computer at times when they need them and at an appropriate level, Academic Systems (1996e) contends that the time the student spends on tasks appropriate to their individual learning needs increases. They spend less time on concepts they understand or learn quickly and spend more time on weak and problem areas.

Technology-mediated learning remodels traditional instructional methodology modifying, but not eliminating the roles of instructor and text. The text book which accompanies and supports the computer-based instruction contains summaries of each lesson concept, worked and partially worked sample problems, homework problems (which are assigned based on a student's performance in a lesson), enrichment activities, practice tests, collaborative activities and cumulative review problems (Academic Systems, Inc., 1996d). Faculty can use their expertise and time where they are needed most, and sometimes lecture, explain and demonstrate. At other times they encourage, ask pertinent questions and guide each student individually through the course (King & Crouse, 1996). A more interactive and individualized learning environment for the student results through the integration of the instructor, text and the multimedia and record keeping capabilities of the computer (Gifford, 1996).

Although mediated learning is in its infancy, much evidence exists for the advantages that CBI, or technology-mediated learning, has over the traditional classroom. This is especially true for courses that are hierarchical, linear and stable in their structure and content (Gifford, 1996). Students with previously expressed math phobia have excelled in Academic System's on-campus technology-mediated setting (Academic Systems, Inc., 1996a). Oklahoma State University reported an eleven percent increase in persistence in developmental mathematics classes with the use of Academic System's methodology (Academic Systems, Inc. 1996c). Because of the full use of text and audio throughout Academic System's technology-mediated mathematics instructional environment, LaGuardia Community College in New York reported that students who lack fluency in English are improving language skills through their math classes

(Academic Systems, Inc., 1996f). Brevard Community College in Florida reported that, after two semesters of using Interactive Mathematics as the only instructional mode for developmental mathematics course offerings, the success rate among students has doubled as compared to the traditional four walls and teacher in front approach (Academic Systems, Inc., 1996b).

In a study during the 1996 Fall term involving 11,991 students from across the country, the pass rate for students in Interactive Mathematics' mediated learning courses was 63 percent while the pass rate for students in traditional classes was 52% (Academic Systems, Inc., 1997). However, no research has been found that identifies the individual student characteristics that predict achievement in the traditional classroom as opposed to the CAI mediated learning classroom. In addition, no research was found comparing the CAI classroom in an on-campus setting to CAI in a distance education setting. This research proposes to examine these deficits.

If CAI works to the advantage of some students, while the traditional classroom works to the advantage of other students, there is a need for discrimination in its use. The first step in reliably predicting student potential for learning is examination of possible predictive or independent variables. Richey (1995) studied adult basic education programs and found that the use of computer managed instruction and pre-assessment levels were the best predictors of achievement. However, Richey did not attempt to use these results to distinguish between those students who would do best in the computer-based versus the traditional class.

Continued research is needed to learn more about the role and use of computerized mathematics instruction at the post secondary level. According to

Academic Systems, Inc., the most useful research projects for the future will be those that allow assessment of the kinds of computer-mediated instruction that are most useful for postsecondary students, determine the kind of mathematics that is best taught via computer, ascertain the kind of student that learns most effectively via the computer, and explore the kind of instructor participation that works best with computer-based implementations (1996). Gifford (1996) addressed topics for further research in mediated learning and asked,

> Is it possible to identify, ahead of time, those students who are most likely to benefit from being placed in a Mediated Learning environment? Similarly, is it possible to identify ahead of time those students least likely to flourish in non-traditional classroom settings? (p. 6).

This research focused on developmental mathematics at the junior college level, and explored the characteristics of students who learn most effectively via computer mediated learning, both on campus and at a distance, as well as in the traditional classroom.

Distance Education

Distance education, at its most basic level, exists when teacher and learner are separated by physical distance, and technology, (such as audio, video, or print), is used to facilitate instruction. Distance education began at least 150 years ago. An advertisement in a Swedish newspaper in 1833 told of the opportunity to study “Composition through the medium of the Post” (Holmberg, 1986). Correspondence study continues even today, although it is supplemented, and many times supplanted, by the application of increasingly sophisticated technology in the form of audio and videocassettes, radio and television, teleconferencing, and computer-based communication and instruction.

Research has shown that students taking distance education courses do so because of convenience, employment requirements, family problems, work related travel, illness or incarceration. These students are generally older, are employed full time, and tend to have higher grades than students enrolled in comparable on-campus classes (Richards, 1994). Adult students are enrolling in increasing numbers on college campuses, and they bring with them work schedules and family responsibilities that make traditional attendance at universities and colleges all but impossible. Distance education provides the flexibility and convenience that adult students need.

Research comparing the achievement of learners who are taught at a distance and those who are taught in the traditional face-to-face, on campus method has been conducted for more than 50 years. The typical finding in these comparison studies is that there is no significant difference between learning (measured by grades, test scores, retention and job performance) in the two different environments. Thomas L. Russell, Director of Instructional Telecommunications at North Carolina State University, maintains an ongoing list of summaries of research which as of January, 1997 had 248 entries supporting the lack of significant difference in learning between the traditional face-to-face classroom and various types of distance learning media. This lack of significance is consistent regardless of course content, the educational level of the students, or the type of media involved.

In 1983, Clark stated:

> The best current evidence is that media are mere vehicles that deliver instruction but do not influence achievement any more than the truck that delivers our groceries causes changes in nutrition . . . only the content of the vehicle can influence achievement (p. 458).

Eleven years later, Clark (1994) restated his opinion:

> It is likely that when different media treatments of the same informational content to the same students yield similar learning results, the cause of the results can be found in a method which the two treatments share in common. . . give up your enthusiasm for the belief that media attributes cause learning (p. 28).

Moore and Kearsley (1996) noted that the average score of groups of learners was the dependent variable in most studies where the question was which learning environment was more effective. Because of the volume of studies resulting in no significant difference, equality of instruction seems to be a question that is not worth devoting more research to. The environment in which learning occurs and the means of communication between instructor and learner have not been proven as significant predictors of success for groups of students. If the medium is well chosen, if support services are in place and functioning, and if all parts of the system are functioning well, the media itself has little consequence on learning outcomes.

There are, however, other significant questions yet to be fully researched concerning the characteristics of individual students in the group rather than the entire group. Willis (1993) asked, “What role does cognitive style play in predicting student success in distance education, and are there valid ways of matching delivery methods to varied learning styles?” (p. 112). Moore and Kearsley (1996) echoed the needs expressed by Willis saying, "There is a need for more research to find out what is the most effective medium for different types of students and what media are most effective for different types of distance teaching strategy and content" (p. 77). This research was designed to add to the body of knowledge in these areas.

Print in Distance Education

The roots of distance education are in correspondence courses. As technological developments have lead to increasingly sophisticated use of other media, the role of print has actually increased in significance (Willis, 1993).

Willis (1993) pointed out that print has many important advantages. It is spontaneous, in that it can be used in any setting without the need for sophisticated equipment. It is instructionally transparent since it does not compete with the content for the learner's attention. Print is non-threatening since it is second nature to most students. It is easy to use, easily reviewed and referenced, cost effective, easily edited and revised, and time effective. However, print also has inherent limitations. It offers a limited view of reality, it is passive and self-directed requiring high learner motivation, and is lacking in feedback and interaction. The use of print is also dependent on reading skill.

Video in Distance Education

Video-based distance education in the United States is pervasive and includes one-way broadcast and cable transmission and two-way interactive television with telephone feedback (Gunawardena, 1990). One way video communication involves delayed or asynchronous interaction between teacher and learner while two-way communication allows real-time or synchronous interaction.

Video provides visual symbols that can help the learner connect thought and experience on the road to understanding concepts taught. Oliver (1994) separates video used in distance education into the categories of televised instruction, video conferencing, pre-produced video, and interactive video. In televised instruction, classroom lectures are broadcast to off-campus locations. Instruction may be enhanced by telephone interaction among remote students and the classroom. Video conferencing features two-way communication and emulates face-to-face meetings. Pre-produced video uses broadcast television to deliver professionally produced content. Broadcast television is convenient but its mass media approach seldom accommodates the individual needs of the learner (Bates, 1994). Interactive video integrates video with the computer. Interaction with course content is attained though computer controlled instructions, activities and feedback. Video can be recorded for later viewing and reviewing. Video cassettes offer flexibility and control by permitting the learner to view instruction at a convenient time and by allowing the learner to pause, fast forward and replay segments of the program.

<u>The Internet in Distance Education</u>

Vannevar Bush believed that the organization of human thought is in the form of associations between concepts and ideas. From this genesis, hypertext arose. The use of hypertext documents may improve comprehension and learning by focusing on the relationship between concepts and ideas instead of isolated facts (Jannasch-Pennell, 1996).

There is limited experience and research on using the Internet as a teaching and learning tool, but computer telecommunications and networking are playing an increasingly important role in distance education efforts (Moore & Kearsley, 1996).

Online education can promote dialogue, interaction and involvement among students as well as between instructor and student. According to Huang (1997) the only part of an online education that is different from the traditional education is lecture. Live lectures are still an important part of traditional campus classes. In hypermedia-based online education programs, live lecture is replaced by hypermedia documents. With linked text and illustrations replacing the traditional classroom components of lecture, text and illustrations, learning on the Internet has looked much like learning in print. However, as hardware and software are turning the corner to make multimedia instruction delivered over the Internet a practical venture this model is changing (Syllabus Press, Inc., 1997).

Computer-mediated education on the Internet describes computer applications that facilitate the delivery of instruction using computers as input, storage, output and routing devices. These applications include electronic mail, bulletin boards, real-time electronic chat and annotation.

Electronic mail is a primary means for distance educators to carry on dialogue with students. Email creates a closed-user group and can overcome any privacy issues members of a class might have. Informal, one-to-one, email can be more effective than even telephone conversations. These communications can be spontaneous without being in the presence of the person's voice. In a traditional classroom, it is hard to forget that the teacher represents authority. However, communication in the form of email has been found to have a leveling effect where the learners and instructor see each other as peers (Markwood, 1994). Email can also be used in a more formal way where the learner submits assignments, and evaluations are sent to the learner. Entire lectures can also be sent via email and, if computers as well as software are properly equipped, can include video and sound.

Bulletin boards make course information available to learners in the class. Learners can also make comments on the class, on their own work, or on the work of others. Many times learner submissions to a bulletin board are submitted through the instructor or manager to ensure they are appropriate for the class topics (Forsyth, 1996). A bulletin board can be similar to email in spontaneity. The major difference is that the communication is one-to-many. When an individual posts a message to the class, every other participant is free to read and respond (Markwood, 1994).

Electronic chat, known as Internet Relay Chat (IRC), is a form of electronic mail. The main feature is that the messages submitted are recorded in real-time allowing participants to send and respond to messages simultaneously. This allows the participants to follow the development of points of view as they and other class members respond to previous messages and conversations. IRC can improve interactivity in an Internet based class by providing some of the spontaneity of live discussions (Willis, 1993).

Annotation allows learners to post questions about information in the course. The teacher can then add comments that appear within the course materials. Other learners can see that some information is annotated and are able to open the annotation and see the comments.

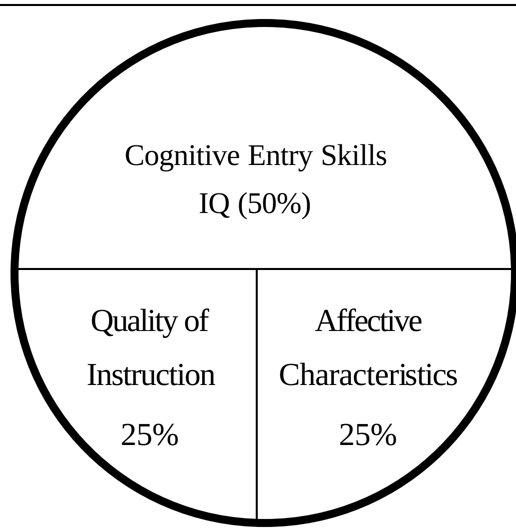
Not all learners find that communication mediated by the computer is satisfactory. In a study of 169 college students who were enrolled in a traditional lecture hall course that utilized computer mediated communication for class communication, Blocher (1997) found that women displayed less engagement with computer mediated instruction and that they felt it was less personal than face-to-face communication.

Variables Contributing to Academic Performance

Dr. Benjamin Bloom (1976), a well-known researcher in the field of educational learning, found that research had demonstrated that when learning conditions are unfavorable for learners they become more dissimilar with regard to learning ability, rate of learning and motivation for further learning. He gathered and performed research focused on the individual learner and found that IQ and cognitive entry skills account for approximately 50% of a student's course grade. Affective student characteristics make up approximately 25% of the course grade and quality of instruction accounts for the remaining approximate 25% (see Figure 2). Excluded from his theory were factors not specifically centered on the student, such as school organization, administration, finance, and teacher training. It is Bloom's framework that this research used as a lens to categorize the factors which effect success in developmental mathematics classes.

Figure 2

<u>Factors Contributing To Student Academic Achievement</u> (Bloom, 1976).



Cognitive Entry Skills and Intelligence

David Weschler, a prominent developer of IQ tests, defined intelligence as "the capacity of an individual to understand the world about him and his resourcefulness to cope with its challenges" (cited in Seligman, 1992, p. 12). There are, however, other viewpoints of what intelligence is. Howard Gardner has promoted the idea of multiple "intelligences" and does not agree that all types of intelligences can be quantified into a single score (Gardner, 1983). Robert Sternberg (1985) proposed that intelligence was made up of conceptual, creative and contextual modes of thinking. The contextual element of Sternberg's model is also known as practical intelligence, or "street smarts," a dimension other than the "school smarts" which Sternberg believed was the construct that conventional IQ tests measure. Locurto (1991) espoused the idea the intelligence can not be understood without its context and defined the construct of intelligence "as the ability to master the skills and information necessary to succeed within a given culture, that is, to succeed at a given point in time with in a defined context" (p. 165). Within the context of mathematics, Nolting (1997) defined intelligence as how fast a student can learn or relearn math concepts.

In examining the locus of intelligence, both heredity and environment have been understood to play a role. Extreme hereditarians have historically used theories of evolution and genetics to support the idea that intelligence is determined at birth. Environmentalists espouse that a person's intelligence can be increased or decreased based on the opportunities and situations experienced during life (Locurto, 1991).

Locurto (1991) acknowledged that IQ correlates impressively with scholastic achievement, but warns against the over evaluation of the predictive power of IQ with respect to education. He states that the correlation between IQ and educational success is, on average, anywhere from about .40 to .60, but that the correlation is most evident at the extremes of IQ. An extremely low-IQ is highly predictive of poor grades, and a somewhat comparable relation is evident for high-IQ people. Locurto was in agreement with Bloom (1976) in that, especially within the average range of intelligence, IQ is only moderately predictive of educational success and other factors must be considered in predicting achievement.

Bloom (1976) stated that "for many purposes we are not interested in the details of how someone developed in a particular way, but in what the individual has already developed in relation to what is yet to be learned" (p. 14). He went on to show that intelligence and aptitudes are stable characteristics, but specific prerequisites and motivation for a particular learning task are modifiable to a greater degree at most stages in an individual's history. In reference to Bloom's model and math classes, Nolting (1997) defined prerequisite (or cognitive entry) skills as how much math a student knows before entering a math class. Adequate prerequisite knowledge is vital in lower-level mathematics where each class builds successively and directly upon the competencies of the previous class.

Affective Factors

According to Nolting (1997), affective student characteristics are those characteristics that affect course grades—excluding how much math the student knew prior to entering the current math class. Some of these affective characteristics include math anxiety, locus of control and learning styles.

Math Anxiety

Tobias (1979) stated that "anxiety is one of the major psychological variables in education" (p. 573). Math anxiety is a "clear-cut, negative, mental, emotional, and/or physical reaction to mathematical thought processes and problem solving" (Arem, 1993, p. 1). Richardson and Suinn (1972) defined math anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide array of ordinary life and academic situations" (p. 551). It is an intense feeling of frustration or helplessness about one's ability to do math (Smith & Smith, 1998).

Green (1990) contended that "mathematics anxiety is implicated frequently as an important affective variable related to poor mathematics performance" (p. 321). Betz (1978) studied the prevalence of math anxiety with several samples of college students and found that "math anxiety occurs frequently among college students and that it is more likely to occur among women than men, and among students with inadequate high school math backgrounds" (p. 441). In a review of empirical literature related to anxiety and college students, Head and Lindsey (cited in Risko, Fairbanks and Alvarez, 1991), drew the following conclusions regarding the relationship between anxiety and academic performance:

- a high anxiety level impedes performance, at least for poor and average students;
- sometimes anxiety can be helpful for students of high intelligence;
- females tend to show a higher correlation between anxiety and performance than males and also tend to have higher levels of anxiety;

- task difficulty has a definite effect on anxiety; and
- certain instructional variables affect anxiety and thus performance (p. 263).

Although some anxiety in a test-taking situation is normal and can even enhance performance, the term “math anxiety” describes those with a more traumatic and extreme condition. Physical manifestations can include headaches, nausea, heart palpitations and dizziness (Zaslavsky, 1996). Some have hypothesized that math anxiety is the brain’s response to threat. Threat combines with a feeling of helplessness and this causes the brain to downshift. When downshifting occurs, students lose the ability to think, the eyes glaze over and they often feel fatigued (Math Matters, 1998).

In the United States, mathematics has such a bad reputation that some physicians use it to induce stress conditions by bombarding patients with mental arithmetic problems (Zaslavsky, 1996). Many of us think of math as difficult and obscure—something of interest only to “nerds” and “geeks.” Because of such attitudes, people who study and enjoy math are often judged as being somehow not quite normal (Smith & Smith, 1996).

Math anxiety can stem from any one or a combination of events in a person’s life. In 1978 Tobias noted typical causes of math anxiety as being the fear of being too smart or too dumb, missing out on an area of mathematics instruction and never gaining competency in it, a distrust of one’s own intuition which disallows deductive thought, the perception that math is ambiguous because of never learning the needed terminology and symbols, the stress of solving for only one right answer, and self-defeating self-talk. Arem (1992) also found that a common reason for math anxiety in students with whom she had worked was negative self-talk about math which she termed “negative math games people play” (p. 14). In addition, Arem found that past embarrassments, poor curriculum, negative experiences associated with learning math, family pressures and expectations, desires to be perfect, and poor teaching methods could often underlie math anxiety. Greenwood (1984) stated that teaching methodology, based on memorization and not on understanding and reason, is the cause of math anxiety. Kogelman and Heller (1994) contended that most people are not taught to apply math concepts to practical adult situations, and that math is taught by insecure professionals who introduce guilt, dislike and anxiety into the subject. In these cases, the negative feelings can become so extreme that otherwise capable, intelligent adults can hardly do math at all.

Many misconceptions and myths surrounding mathematics have promoted societal acceptance of mathematics illiteracy. Many authors (Smith & Smith, 1998; Zaslavsky, 1996; Arem, 1993; Tobias, 1978) discussed the erroneous idea that women are innately inferior in mathematics. As recently as a hundred years ago people assumed that because men are larger and heavier their brains must be larger and heavier also. When research demonstrated that intelligence was not related to brain weight, male intellectual superiority was attributed to high levels of uric acid in the male body and the draining off of “life forces” by women’s wombs (Sherman, 1977). Psychologists in the 1980’s arrived at the conclusion that gender differences in achievement and attitude toward mathematics resulted from superior male mathematical ability. A few years later these same psychologists hypothesized that the supposed male superiority in spatial ability was due to the effect of the male sex hormone testosterone in the prenatal stage (Benbow & Stanley in Zaslavsky, 1996). The media widely publicized these conclusions, although researchers in the field criticized the studies upon which the conclusions were based (Leder, 1990; Tartre, 1990). Parental attitudes about their daughter's abilities in mathematics were negatively influenced by the publicity and predictably, mathematical achievement in girls fell (Jacobs & Eccles, 1985).

Although many women today profess disbelief in the existence of innately different mathematical ability levels in men and women, they do see math as unfeminine. Generations of gender bias continue to effect the perceptions of many people of both genders when it comes to mathematics (Smith & Smith, 1998). Math anxiety occurs frequently among college students, and more frequently among women than men and among students with poor high school math backgrounds (Betz, 1978). This anxiety contributes to the fact that females tend to rate their performance below that of males, even when mathematics achievement is equal (Leder, 1990).

Research supports a significant effect for gender in predicting achievement in remedial mathematics. Branum (1990) examined 30 sections of remedial mathematics courses and found that gender, along with the number of semesters of high school algebra, was a significant predictor of achievement.

The myth of innate inferiority in mathematics extends beyond women to include poor people and people of color (except Asians). Rather than a genetic predisposition for poor math achievement, there is a strong correlation between poverty and mathematics achievement. The schools which poor people attend may be inferior, early childhood education is limited, potential role models are often non-existent and society tells them that they are not worthy (Zaslavsky, 1996). The National Science Board attributed the low achievement scores of these students "directly to both blatant and subtle racial discrimination (including stereotyped racial attitudes), extreme poverty, and, in some cases, unsatisfactory rural or urban condition" (1983, p. 13).

Miller (1998) and Smith and Smith (1998) note three other misconceptions negatively effecting mathematics achievement as being: people who are good at math never make mistakes and concentrate on getting the right answer, to be good at math one has to be good at calculating, and math requires logic, not creativity or expressiveness.

There are people of all ages and from all walks of life who fear and avoid math, and their plight can be devastating not only in test-taking situations, but also in learning mathematical concepts (Betz, 1978). Various methods exist for overcoming the emotional responses and learning gaps associated with mathematics anxiety. Tobias (1979) found that "the adaptation of instructional materials so that interference by anxiety can be minimized, and the treatment of anxious individuals in test anxiety reduction programs" (p. 579) are necessary to reduce anxiety. Many colleges offer clinics for adults to help them become comfortable with mathematics. These programs concentrate on psychological aspects, math tutoring or both (Zaslavsky, 1996). Smith and Smith (1998) advise constructively managing math anxiety by "taking possession." This strategy involves understanding that feelings of math anxiety are common but that they do not indicate inferiority or inability to learn math. Sharing feelings and past negative experiences about math were also found conducive to making oneself completely conscious of barriers to math achievement, and in understanding that these negatives experiences and reactions to them are shared by almost everyone.

Parker (1998) uncovered a six-stage process of overcoming math anxiety. First, adults must perceive a need to become more comfortable with math. Without the perception of need, there is no motivation to expend any effort. Second, a commitment to address the problem is needed. Third, math-anxious adults must take specific action to increase their comfort level with math. These actions include improving study techniques, using learning tools, attending tutoring sessions as well as learning and applying relaxation techniques. Fourth, adults must recognize that they are no longer math anxious and accordingly, their perspective on mathematics has changed. Finally adults who overcome their math anxiety should become a part of a support system to help others seeking help with math. Hembree (1990) performed a meta-analysis of 151 studies to scrutinize the construct of mathematics anxiety and not only found that mathematics anxiety depressed performance, but found improved mathematics performance improvement consistently accompanied valid treatment.

Research supports the existence of a significant relationship between mathematics anxiety and mathematics performance. In the examination of fourteen studies investigating undergraduates, Cook (1997) found only four studies that did not find a significant relationship between mathematics anxiety and mathematics performance. However, in a study of 501 community college students, Cook found that although women had higher levels of math anxiety than men, their course grades were also higher.

Math anxiety is frequently found to be one of the factors particularly associated with poor developmental mathematics achievement. In a qualitative study, Turkel (1996) followed 32 college-aged students enrolled in developmental classes and found that math anxiety was a common problem. Green (1990) studied the relationships among test anxiety, mathematics anxiety, teacher feedback and achievement of 132 undergraduate students in remedial math classes. It was found that the multiple regression equation containing all of the predictor variables was highly significant, indicating that each of the variables had an overall prediction of the subjects' grades for the course. The instructional method used in Green's study was traditional lecture. Unanswered, and in need of further research, is whether these factors have predictive or discriminative value for different pedagogical methods.

There are several instruments available for measuring levels of math anxiety in adults. Suinn's Math Anxiety Rating Scale (MARS) is a 98 item instrument of everyday situations rated for level of anxiety and is normed for U.S. adults and college students. Administration of the test requires no special qualifications, and the test booklet provides all the information required by the examinee. The test can be completed by most college students in less than 20 minutes (Llabre, 1984). It is available directly from the author, Richard M. Suinn, Ph.D., and the cost is $60 per 100 scales (R. M. Suinn, personal communication, September 3, 1998).

Both stability and internal consistency estimates have been used to determine the reliability of the MARS. Mars & Suinn (1972) found a test-retest reliability coefficient of .85 and internal consistency reliability, coefficient alpha, of .97 for 397 college freshman showing that the average intercorrelation of the items in the test is high. These scores show that the test is highly reliable and also indicates that the test items are primarily measuring a single homogeneous factor, presumably mathematics anxiety (Richardson & Suinn, 1972).

More recently Dew, Galassi and Galassi (in Llabre, 1984) studied the MARS and reported test-retest reliability coefficients of .86 for women, .95 for men and .87 for the total sample of 125 college women and 30 college men. Dew (in Llabre, 1984) found internal consistency reliability in a sample of 550 female undergraduates of .97 and 209 male undergraduates of .988. The value of the combined sample was .96.

Questions have arisen about the unidimensionality of the MARS. Rounds and Hendel (1980) conducted research that suggested that the MARS measured at least two distinct dimensions which were labeled as mathematics test anxiety and numerical anxiety. Based on factor-analytic studies Llabre (1984) also suggested that two rather than one score should be derived from the MARS. Again, the dominant factor for the MARS appeared to be testing or evaluation situations and the secondary factor related to arithmetic operations. In both studies, mathematics test anxiety appeared as the primary dimension and number anxiety was the secondary dimension found in the 98-item MARS. Other critics (Alexander & Martray, 1989) suggested that the full scale MARS is lengthy and cumbersome to score and that a shorter, equivalent scale would make it a shorter, easier test to administer and score.

Fennema and Sherman (1976) developed nine, domain specific, Likert-type scales measuring attitudes related to mathematics learning in high school students. The scales were designed to be used as a total package to assess a variety of attitudes toward mathematics learning, or to be used individually. Each of the scales was designed to assess an attitude related to the study of mathematics. One of these scales contained 12 items used to measure mathematics anxiety. This scale was intended to assess "feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics" (p. 4). Norms were based on two large high school samples, and a split half reliability coefficient of .89 was reported. Since this scale was designed for high school subjects, it was not selected as a appropriate instrument for this research.

Plake and Parker (1982) devised a 24-item shortened version of the MARS in order to provide a more efficient measure of statistics or mathematics course-related anxiety. Their revised scale yielded a coefficient alpha reliability estimate at .98 and correlated .97 with the full scale MARS. They also found two clear factors emerged from the MARS which they labeled “Learning Mathematics Anxiety” and “Mathematics Evaluation Anxiety” (p. 551). This scale presented a useful and apparently psychometrically sound equivalent to the MARS for diagnosing mathematics anxiety in a statistics class. Since this scale was designed primarily for measuring mathematics anxiety in a statistic course, much of the wording was not appropriate for the present study.

In 1989, Alexander and Martray proposed that the MARS could be reduced to a unidimensional subset and developed the Abbreviated Mathematics Anxiety Rating Scale (AMARS) which was not necessarily focused on statistics. They found three factors defining the dimensions of mathematics anxiety, defined through factor pattern coefficients, as being math test anxiety, numerical task anxiety and math course anxiety. Through a series of one-way analyses of variance, 25 items from the original 98-item MARS were found to have statistically significant differences. According to Alexander and Martray, (1989):

> Coefficient alpha was .96 for the fifteen items associated with Factor I (Math Test Anxiety), .86 for the five Factor II (Numerical Task Anxiety) items, and .84 for the five Factor III (Math Course Anxiety) items. These coefficients compare favorably with the .97 coefficient alpha reported by Richardson and Suinn (1972) for the full scale 98-item MARS (p. 147).

<u>Locus of Control</u>

The construct of locus of control is a component of personality that functions as a determinant of behavior. If one believes the outcomes of their actions are contingent on their own behavior, this person has an internal locus of control orientation. The locus of control is external when events are perceived to be the result of luck, fate, the environment, or the control by others of anything else outside of personal control (Marsh & Richards, 1987; Rotter, 1966, 1975). Simply put, locus of control is a measure of the perceived relationship between actions and outcomes (White, 1990).

Although the concept of locus of control could appear to be bimodal, the perceived relationship between effort and outcome is not all-or-nothing, but varies by degree. At times, people see outcomes partially related to their own actions, but also related to the influence of other factors such as luck, fate or chance (Rotter, 1966). In 1975, Rotter clarified the nature of the construct stating, "we assumed that with internal-external control something approximating a normal curve described the populations we were interested in" (p. 57).

Theoretically, social learning theory was the background for the conception of the locus of control construct. Social learning theory postulates that reinforcements strengthen expectancies that the same reinforcement will follow the same behavior or event in the future. If the reinforcement does not occur in the future, the expectancy is lessened. The logic is that when reinforcement (or outcome) is not perceived as being dependent on one's own behavior, expectancy will not increase as much as if the outcome is seen as being contingent on behavior (Rotter, 1966). In the expectancy theory of motivation, Vroom (in Hersey & Blanchard, 1993), postulated that when there is "a positive relationship between effort and performance, a positive relationship between good performance and rewards, and the delivery or achievement of valued outcomes or rewards" (p. 30), motivated behavior increases.

Robinson and Shaver (1973) identified the factors that effect the development of locus of control as either episodic or accumulative. Episodic events are those that are highly important and occur only during a restricted time period. Examples of these episodic occurrences include the death of a loved one, an atypically low test grade, a community disaster or a temporary series of accidents. These types of events can act as temporarily externalizing factors in an individual's locus of control orientation. As time passes after an episodic event, the affected individual is likely to return to their previously held locus of control levels. However, if the episodic events continue to last for an extended period, they may fall under the dimension of "accumulative antecedents."

Accumulative events refer to those events that are more or less continuous in an individual's life. These life circumstances can influence the development of internal and external locus of control orientations. Robinson and Shaver (1973) identified three important accumulative categories as being social discrimination, prolonged incapacitation disability, and parental child rearing practices.

An individual's locus of control orientation can change. Phares (1973) argues that internally oriented individuals tend to become more internally oriented after successes and more externally oriented after failures. Internals may react this way because they attribute their successes and failures to personal abilities. Since those with a more external orientation see a low correlation between the their effort and either success or failure, their orientation is not as likely to change. Other research (Anderson, 1977) found that internals who improved performance became more internal, and externals who improved performance did not significantly become more external. However, internals who had poor performance demonstrated no change in locus of control and externals who had poor performance showed a strong tendency to become more external.

Many other studies have included the construct of locus of control. By 1975, Rotter stated that "well over 600" (p. 1) had taken place. Locus of control continues to be a topic of interest to researchers. In a study of the effect of locus of control and attitudes toward intelligence on study habits of 294 freshman students, Hazard (1997) found that at post-test, there was a strong relationship between locus of control and first-semester GPA. In her review of literature, Wills (1996) found that locus of control was often predictive of academic success among college students; however, few studies had used it as a predictor of success among academically disadvantaged students. She studied 44 academically disadvantaged students who had each completed developmental level mathematics and English classes. In these students, locus of control did not seem to have any discriminating properties between those students who succeeded academically or those who did not succeed academically. It is possible that the small sample size in the study limited the variability in the results.

Some research has found age or gender differences in locus of control. Kay (1989) found that males appeared to have a more internal locus of control than females with respect to computers ($p < .001$). She attributed this finding to the higher computer literacy scores for the males, reasoning that more knowledge about computers helps people feel that events related to the computer are dependant on his or her actions. Nunn (1994) found females were more external than males and also found older groups of students were more internally oriented.

Locus of control has also been found useful in predicting dropout rate in distance education settings. Parker (1994) studied factors affecting dropout from distance education and found that dropout rate was predicted with 85% accuracy by a combination of locus of control and source of financial assistance. This finding agrees with Alman and Arambasich (1982) who found that students with an internal locus of control showed a greater degree of persistence.

In studying student adjustment to college, Martin and Kay (1989) found that although attendance at orientation had no significant effect, locus of control was significant. Students with an internal locus of control were found to be significantly better adjusted to their new college setting than were their external counterparts.

Locus of control has been shown to relate to achievement in several studies. Dille and Mezack (1994) studied locus of control and learning style as predictors of high risk in college students. This research team used the Rotter I-E Locus of Control scale with 151 students enrolled in a telecourse. In a multiple regression analysis with significance at the .0077 level, they found that students with a more internal locus of control were more likely to be successful and earn a higher grade.

Wilhite (1990) examined the relationship between self-efficacy, study behavior, and academic course achievement using self-efficacy and locus of control as predictors of achievement. The sample consisted of 184 college students enrolled in an introductory psychology course. The subjects were drawn from six different sections of the class. A stepwise multiple-regression analysis of achievement as measured by final grades was performed. Scores on a self-assessment measure of memory ability (measured by the Everyday Memory Questionnaire) and locus of control (measured by the Adult Nowicki-

Strickland Internal-External Control Scale) functioned as the best predictors of final course grades. Locus of control was found to be independent of academic self-concept or self-worth (R=.572, B=.311, standard error of B=.061, ∃=.301, p<.0001). This lack of relationship may suggest that locus of control is a more important predictor of academic achievement than self-concept, at least in some settings. Results also showed that the more positively students assessed their own memory ability, the more external their locus of control and the more positive their self-concept of academic ability, the better the student tended to do in class. The finding of an external locus of control being associated with higher grades is in contrast to most other studies. However, Lefcourt (1982) was noted by Wilhite as suggesting that such findings point to the need for studies of how characteristics of the academic context may mediate the relationship between locus of control and achievement. This research was designed to further the scholarly knowledge in this area since the relationship of locus of control and achievement was studied in the contexts of the traditional classroom and the computer-based instruction classroom (on campus as well as at a distance) for developmental mathematics.

Learning Styles

Learning styles are an explanation of the way people learn. Learning style theory identifies the factors that effect a student's ability to practice, internalize and retain new information. Additionally, learning styles include "motivation, on-task persistence verses the need for multiple assignments simultaneously, the kind and amount of structure required, and conformity versus nonconformity" (Dunn, Beaudry & Klavas, 1989). Reiff (1992) defined learning styles generally as "a set of factors, behaviors, and attitudes that facilitate learning for an individual in a given situation." Research has shown that matching a student's strongest learning style with the instructional style improves learning, and that students who understand their learning style can improve their learning effectiveness (Nolting, 1997).

Learning styles theories and inventories are categorized in various ways. In a review of published learning style inventories, Hickcox (1995) used Curry's three layer model to categorize learning style models into three main groups: (1) those which measure personality related preference, (2) those which measure information processing preference, and (3) those which measure instructional and environmental preference. Hickcox described Curry's three groups like the layers of an onion:

> The first layer (or core) presents learning behavior as controlled at a fundamental level by the central personality dimension. The middle layer centers around a theme or information processing dimensions. The outer layer, influenced by the interaction of the environment, is based on the theme of instructional preferences. The outermost layer of the model, and the most observable, is the instructional preference learning style conceptual approach (pps. 28-29).

The outermost layer of Curry's (in Hickcox, 1995) model included instructional and environmental preference inventories. These inventories assist in the identification of student study or work setting needs. Rita and Kenneth Dunn may be the best known researchers of learning styles whose work fits into Curry's instructional and environmental preference category. Dunn and Dunn have published in many educational journals and have written a number of books. They have also presented seminars on learning styles across the United States and internationally.

Over the years, Dunn and Dunn's model of learning styles has undergone several refinements (R. Dunn & K. Dunn, 1975 & 1993; Dunn, 1981). By 1993, Dunn & Dunn's learning styles model used a person's ability to master new and difficult knowledge to describe learning style. In this model there are five dimensions: environmental, emotional, sociological, physiological and global (which is determined through correlations of the other components of the model).

The Productivity Environmental Preference Survey (PEPS) is an instrument based on the Dunn and Dunn learning styles model and used to analyze the instructional and environmental preferences of adults. According to Price (1996), it provides "information concerned with the patterns through which the highest levels of productivity tend to occur" (p. 5). This instrument is designed to measure preferences in (a) immediate environment, (b) emotionality, (c) sociological needs and (d) physical needs. These main areas are subdivided into twenty more specific preferences:

> 1. Sound, 2. Light, 3. Warmth, 4. Formal/Informal Design, 5. Motivated/Unmotivated, 6. Persistent, 7. Responsible (Conforming), 8. Structure, 9. Learning Along/Peer Oriented, 10. Authority-Oriented Learner, 11. Several Ways, 12. Auditory Preferences, 13. Visual Preferences, 14. Tactile Preferences, 15. Kinesthetic Preferences, 16. Requires Intake, 17. Evening/ Morning, 18. Late Morning, 19. Afternoon, and 20. Needs Mobility. (p. 6).

According to Price (1996), these questions tend to indicate the way in which an adult prefers to work or concentrate.

In a survey of research, Dunn, Beaudry and Klavas (1989) cited a 1988 study by Bruno which found that right-hemisphere community college adult math underachievers preferred learning with sound and intake. They wanted tactile and kinesthetic instructional resources and mobility significantly more often than their left-hemisphere counterparts, who preferred bright light and a formal design. When the predominantly right-hemisphere students were taught alternately with both global and analytic methods, they achieved statistically higher test scores through the global rather than through the analytic resources.

Perceptual learning styles seem to be linked to mathematics anxiety. McCoy (1992) examined the relationship between mathematics anxiety and perceptual learning style preferences in 78 preservice and inservice elementary school teachers. Most of the sample were women, and the study revealed a significant relationship between math anxiety and the tactile/kinesthetic mode. Cook (1997) studied 501 community college remedial and basic level mathematics students and found that math anxiety level was significantly correlated to one or more learning styles for all groups studied. "For female subjects, there were significant positive correlations between math anxiety level and two learning styles: tactile/kinesthetic and audio. For males there was a significant correlation between math anxiety level and audio learning style only" (p. vi). Cook recommended further research with a more comprehensive learning style instrument as well as a mathematics performance measure that would include incomplete grades and withdrawals.

Dunn, Griggs, Olson, Beasley and Gorman (1995) found that the content area most responsive to learning-style accommodation was mathematics, followed by language arts and other subjects. Students with strong learning-style preferences showed greater academic gains as a result of congruent instructional interventions than those students who had mixed preferences or moderate preferences. College and adult learners also showed greater gains than elementary school learners or secondary school learners.

Dunn, et. al (1995) conducted a meta-analysis of 42 learning style studies. A jury determined that six had serious threats to validity according to Lytton and Romney's Quality Rating Scales. The 36 remaining studies involved 3,181 subjects and the results of these studies suggested that students whose learning styles are accommodated are expected to achieve 75% of a standard deviation higher than students who have not had their learning style accommodated.

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The PEPS was developed through factor analysis and tested on a non-random sample of 589 adults. 31 factors were identified with eigenvalues greater than 1.00 and which explained 65 percent of the total variance on the PEPS. The factors and the items were then submitted to an orthogonal rotation to maximize the variance of the squared factor loading. The number of iterations for the rotation was 50 and the precision level was 1.00. The 31 factors were found to account for 65 percent of the variance and the eigenvalues associated with each factor ranged from 7.89 to 1.02 (Price, 1996).

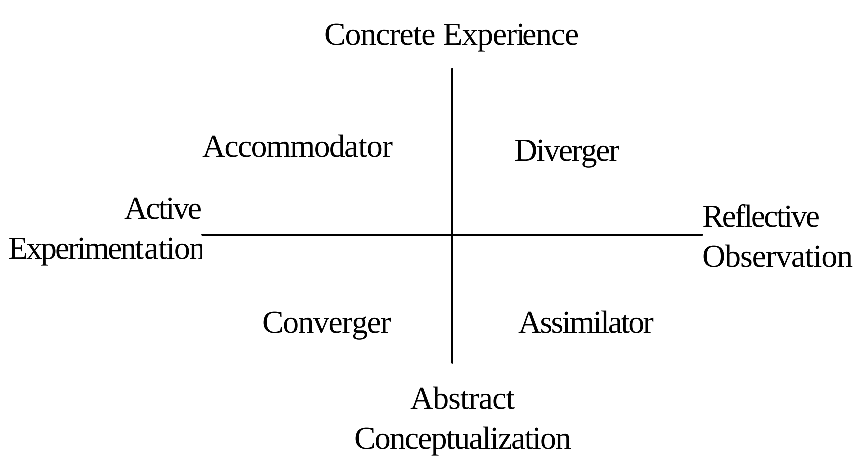
Reliability scores for the 20 factors range from .48 for authority-oriented learner to .91 for light, with 90 percent of the reliabilities equal to or greater than .60. "The PEPS has been revised based on a careful review of each item. Analysis included a reevaluation of the items that could be interpreted in different ways and were not entirely clear in their assessments of the defined area" (Price, 1996, p. 14).

The middle layer of Curry's model includes information processing inventories. The results of this type of inventory provides in-class learning style preferences. Kolb's theory of learning style is in this category. Much learning style literature is based on studies of children, but David Kolb studied experiential learning and learning techniques based on experiences individuals have throughout their lives. Kolb's work was somewhat of a breakthrough since he formulated the results of his findings into a learning style model (McCarthy, 1981) and analyzed different types of learners. Kolb found that dominant learning abilities are the result of heredity, past life experiences and the demands of the present environment. Kolb (1984) postulated that individuals differ in the way they learn along two dimensions. These first dimension contrasted concrete experience and abstract conceptualization; the second dimension contrasted active experimentation and reflective observation. Figure 3 shows how Dr. Kolb combined these dimensions of perceiving and processing and found that people fall in one of four different places on his model: (1) the converger: abstract conceptualization and active experimentation; (2) the diverter: concrete experience and reflective observation; (3) the assimilator: abstract conceptualization and reflective observation; and (4) the accommodator: concrete experience and active experimentation. He also theorized that while learning styles indicate a preference for one mode, they do not always indicate the absence of other modes.

Kolb developed the Learning Styles Inventory (LSI) in 1976 based on studies of 1,446 adults. It was a nine-item inventory in which individuals were asked to rank order four words that described their learning preferences. Kolb revised the LSI in 1985 to improve its validity and reliability. The revised instrument consists of 12 sentence completion items that ask individuals to describe how they learn in specific situations. The results are two combination scores that indicate the individual's preference for abstractness or concreteness and for action or reflection.

Figure 3

<u>Kolb's Learning Style Model</u>



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Kolb's LSI has strong internal reliability and is based on a population that was "ethnically diverse, drawn from a wide range of careers with an average education of two years in college" (McBer, 1986, p. 72). Much research has been done using Kolb's LSI as a measure of learning styles. Richey (1995) used Kolb's instrument and found that learning style had no correlation to achievement in adult basic education students; however, a significant correlation was found between persistence and learning style with accommodators having higher persistence rates than assimilators.

Hudak and Anderson (1990) used the LSI to predict success in college-level statistics and computer science courses. Their findings suggested that concrete experiencing (as measured by the LSI) hindered success whereas formal operationalism (as measured by the Formal Operations Reasoning Test (FORT) was advantageous in achieving success. Stepwise inclusion of the other three learning style variables did not significantly increase the classification rate for successful and unsuccessful students.

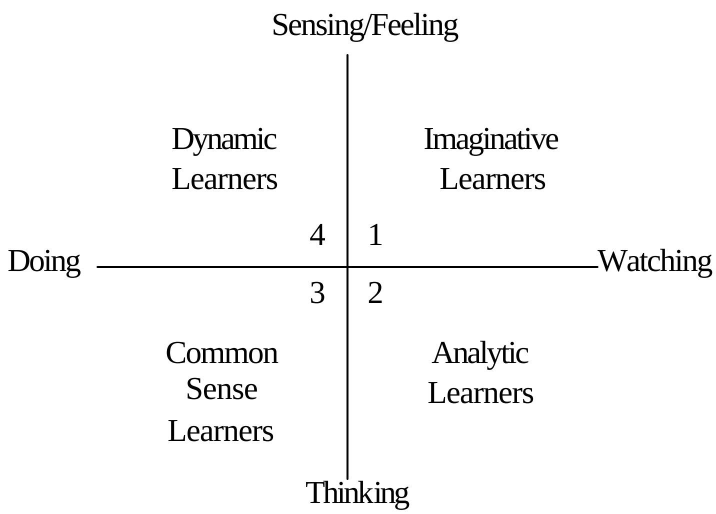
The innermost portion of Curry's personality include learning style inventories that offer information for self-knowledge and how it may relate to learning settings. The personality constructs measured by this type of an instrument are underlying and relatively permanent. One of the best known indicators of personality types is the Myers-Briggs Type Indicator, which was designed in 1962 (Myers, 1962). This inventory attempts to measure four psychological types as first defined by Jung: (1) feelers; (2) thinkers; (3) sensors; and (4) intuitors (McCarthy, 1981). The patterns of results are used to predict attitudes and behavior.

McCarthy (1981) applied Jung's constructs of feeling, thinking, sensing and intuition along with Kolb's constructs of concrete experiential, reflective, abstract and active learners as the theoretical basis for the 4MAT system. Like Kolb, McCarthy visualized the 4MAT system as a four quadrant model examining how people perceive and process reality (see Figure 4). According to McCarthy (1991) those who perceive in a sensing/feeling way perceive through their senses and immerse themselves directly. Those who think through experiences analyze what is happening and make abstractions. Learners need both dimensions of perception to fully understand their experience. Processing is another dimension of learning. Some people watch first while others do first. Watchers reflect on reality, relating what is happening to their own experiences and choosing their perspectives on the new event. Doers tend to act immediately on new information and try things out before they reflect.

McCarthy (1991) continued to describe the types of learners found in each quadrant of the model. Those who perceive information concretely and process it reflectively are termed imaginative learners. Those who perceive information abstractly and process it reflectively are termed analytic learners. Those who perceive information abstractly and process it actively are termed common sense learners. Those who perceive information concretely and process it actively are termed dynamic learners.

Figure 4

McCarthy's Learning Style Model



According to McCarthy and St. Germain (1998b), the difference between Kolb's theory and McCarthy's model is in the way learning style is classified. For Kolb, individuals are classified into one of four learning styles based on a mathematical computation which derives from the individual's score on a self-report instrument which measures preferences for perception and processing. This style is then described in terms of individual behaviors. McCarthy emphasizes the independent yet related nature of all four of Kolb's aspect of style. She describes a learning adaptive mode, two supporting modes and a least preferred mode. Using her 4MAT Model, McCarthy draws attention to the commonalties in learning that individuals share, while also indicating the extent to which the behaviors of others must be accommodated (p. 8-9). McCarthy does not classify learners into a single style. Rather, learning style is the relationship between and among Kolb's four quadrants along with the mode that is preferred.

McCarthy (1991) also deepened and extended Kolb's model by including the concept of hermisphericity. Hemisphericity refers to the different functioning of the right and left sides of the brain. Speech functioning has been shown to reside in the left side of the brain, while spatial capability resides in the right side. In addition, the left brain does lineal, sequential processing while the right brain uses a more global process where "data is perceived, absorbed and processes even while it is in the process of changing" (McCarthy, 1980, p. 71). While many individuals have a tendency to rely more on either their right or left side of the brain, others are more balanced in their processing. McCarthy (1991) sited Bogen (1969, 1975) as the source for the ideas that the two halves of the brain process information differently, both hemispheres of the brain are important in processing and individuals rely more on one information processing mode than the other. Studies were conducted and it was found that within each of the four learning styles quadrants there are right-mode, left-mode and whole brain learners. Thus her full model contains eight components. The full cycle of instruction should include eight parts with right and left-brain dominate activities presented in each of the four types of learning. Although the study of brain hemisphericity is fascinating, it was decided that its inclusion in this study would make the design and results of the study overly complex.

The 4MAT Learning Type Measure (LTM) (McCarthy & St. Germain, 1998a) measures the strength of four types of learning: those who perceive information concretely and process it reflectively are termed imaginative learners and are designated as Type 1 learners; those who perceive information abstractly and process it reflectively are termed analytic learners and are designated as Type 2 learners; those who perceive information abstractly and process it actively are termed common sense learners and are designated as Type 3 learners; and those who perceive information concretely and process it actively are termed dynamic learners and are designated as Type 4. The LTM is based on the work of Jung, Kolb, Lewin, Myers, Bogen and McCarthy.

> Specifically reflected in the LTM are (1) situational adaptations of Jung's constructs of feeling, thinking, sensing, intuition, extroversion and introversion. (2) behaviors modeled after Kolb's constructs of concrete experiential, reflective, abstract and active learners, (3) representations of hemisphericity drawn from Bogen, and (4) McCarthy's field work. (McCarthy & St. Germain, 1998b, p. 8-9).

Since brain hemisphericity was not be considered in this research, the portion of the LTM which measures hemisphericity (Part B) was not examined.

In considering the construct validity for learning type, which is to determine if one learning type is distinguishable from the others, 390 people were administered the LTM. Only 10 people had a tie between learning types. In addition, 70% of the respondents had differences between their two most highly favored learning types (McCarthy & St. Germain, 1998b).

Concurrent validity was examined by comparing the LTM to the Kolb Learning Style Inventory (LSI). Using a contingency table analysis, it was found that there was a 61.1% agreement (chi-square=137.4286, df=9, $p<.0001$; Cramer's V=.51163, contingency coefficient=.66323) between the two measures. In addition the LTM was compared to the Myers Briggs Type Indicator (MBTI) and significant relationships were found between the Feeling score on the MBTI and the Learning Type 1 score, the Introvert, Thinking, and Judging scores on the MBTI and the Learning Type 2 score, the Sensing score on the MBTI and the Learning Type 3 score, and the Extrovert, Intuitive and Perceiving score on the MBTI and the Learning Type 4 score (McCarthy & St. Germain, 1998b).

Reliability of Part A of the LTM was also examined among the same 390 subjects. Internal consistency, as measured by the Cronbach alpha statistic was: Learning Type One=0.853; Learning Type Two=0.835; Learning Type Three=0.767; and Learning Type Four=0.885. In a test-retest, the coefficient of stability was found to be .71 which is an acceptable level of stability (McCarthy & St. Germain, 1998b).

Scott (1994) examined the legitimacy, usefulness and intellectual soundness of the 4MAT model. No direct criticism of the 4MAT model was found in the literature. Legitimization of the 4MAT model has been widespread. Many school districts across the nation were found to use the 4MAT concepts. In addition, Educational Leadership included five articles on 4MAT in its October 1990 issue and various dissertations have used and examined the 4MAT model. Legitimacy and intellectual soundness is also shown through congruence with other theoretical work including Bruner, Maslow, Dewey and others.

Ault (1986) used an abbreviated version Learning Type Measure (LTM) that was based on the 4MAT system in a study that attempted to relate learning styles theory to adult students in a technical college. Students in two general studies classes were taught with all four methods (through the use of varied teaching methods) as suggested by the 4MAT system. This resulted in significant improvement in student attitudes and performance and increased teacher satisfaction and effectiveness.

Cordell (1991) conducted a study on 200 adult subjects to determine whether or not learning styles as assessed by the 4MAT learning styles inventory affected the outcome of learning with two computer based instruction (CBI) design strategies; linear and branching. The dependent variable was learning outcome as measured on a posttest and the independent variable was instructional design with learning style as a moderator. All 200 subjects took the 4MAT learning style inventory and their learning styles were determined. Each subject was then randomly assigned to either the linear or branching health tutorial. The number of correct and incorrect responses was recorded by the computer. Results showed significant main effects for instructional design, no main effects for learning style and no effects for the interaction of instructional design and learning style. Cordell suggested further research examining the demographics of age, gender and education related to outcomes of CBI would be of great value. The study did not compare traditional classes or distance classes with the CBI classes, and only one mediating variable (learning style) was taken into account. The study was designed to fill in some of the gaps in knowledge left by Cordell's study.

Although learning styles are related to achievement in some studies and not in others, there is enough evidence to warrant including learning style as a predictor of success for developmental mathematics students. This research furthered the body of scholarly research by examining the relationship of learning style to three different pedagogical methodologies (traditional classroom, on-campus CBI and CBI at a distance) in developmental mathematics classes at the community college level.

Quality of Instruction

Nolton (1997) defined the quality of instruction as the effectiveness of math instructors when presenting materials to students in the classroom and math lab. This effectiveness, depends on "course textbook, curriculum, teaching style, extra teaching aids (videos, audio cassettes), and other assistance" (p. 52). Each of these factors can affect a student's ability to learn in the math classroom.

Effective teaching is understood to be a crucial component of high quality instruction. Schonwetter, Perry and Struthers (1993) found that high levels of organization in instruction lead to consistently good student learning outcomes. Organization was found to have a strong relationship with student attention and achievement outcomes, and that high organization along with high expressiveness produced an optimal learning condition. Characteristics for effective mathematics teachers have been identified in the American Mathematical Association for Two Year Colleges (1995):

> According to Guidelines for the Academic Preparation of Mathematics Faculty at Two-Year Colleges (AMATYC, 1992), effective teachers are reflective, creative and resourceful. They use a variety of instructional methods and respond to the needs of the particular students they are teaching. Furthermore, they model behaviors they wish their students to exhibit and treat their students and colleagues in a caring and helpful manner. Faculty must provide careful academic advice, be flexible about ways in which students can meet course requirements, and simultaneously provide support to and demand commitment from their students (p. 51)

King and Crouse (1998) identified the aspects of an ideal learning environment for mathematics as one that:

- focuses on an individualized-learning approach providing constant feedback on progress,

- offers attractive and motivating materials,
- appeals to the sophisticated consumer of technology yet is comfortable for the nontechnical students,
- incorporates all the rigor and requirements of the curriculum yet permits students to progress successfully from simple to hard concepts,
- allows students to progress without wasting time but taking time when needed,
- offers a curriculum built on the problem-solving model mot motivating to adult learners and providing solid preparation for all college credit courses,
- uses a grading system that allows students to persevere through two semesters if necessary without a penalty (p. 2) .

In discussing the future of higher education, Johnstone (1993) said that the most significant advances will come through greater attention to the individual learner. Rather than focusing on enrollments, courses taught, credit or classroom hours assigned, the input of the faculty and staff should be related to learning:

> When the object of critical inquiry is learning and learners, rather than merely teaching and teachers, an enormous potential opens for increased learning through reducing the student's time spent on activities other than learning, lessening the aimless drift of students through prolonged undergraduate years, and challenging each student up to his or her learning potential (p. 1).

Johnstone's (1993) contention is that mastery learning should be the standard. In this model, level and content are prescribed but the time spent learning becomes a dependent variable rather than a fixed length of time. Baker (1998) agrees, citing the need to move away from industrial-age, standardized mass-production approaches to teaching and learning toward a more learner-centered approach, offering convenient and customized learning experiences sensitive to the needs of diverse students. In addition, he sees the need to move beyond traditional instruction, which is tied to specific times, places, texts and lectures.

Nolton (1997) contended that the most important quality variable is the compatibility of an instructor's teaching style with the student's learning style. If students cannot find a math instructor to match their learning style, strong study skills and use of a math lab or learning resource center can compensate for most of the mismatch.

Focusing on affects and achievement in different instructional conditions, Schonwetter, Perry and Struthers (1993) assessed students' perceptions of control and success. To measure these factors, two questions were given regarding a prelecture test: "How much control did you have over your test outcome?" and "How successful did you feel at the end of the test?" (p. 233). Students were assigned to instructors who were expressive or unexpressive in their presentation of material. Instructor expressiveness was defined by "low interference teaching behaviors, including movement while presenting material, gestures with hands and arms, eye contact with students, voice inflection, minimal reliance on lecture notes, and humor that is relevant to lecture content" (p. 228).

In either instructional setting, high-control/high-success students demonstrated the highest achievement. Surprisingly though, low-control/low-success students demonstrated higher levels of achievement and confidence than the low-control/high-success or high-control/low-success groups. Several explanations for this unusual finding were offered. One explanation may be that low-control/low-success students are more cognitively cautious when entering a learning environment. Because of this, they protect their self-esteem by underestimating their perceptions of control and success. Another explanation may be that the high-control/high-success and the low-control/low-success groups both have compatible perceptions. It is possible that control-success incompatibility is related to maladaptive student learning experiences.

Summary

This chapter has reviewed literature that is important for the design of this study. The section began with a review of developmental mathematics and the methods of instruction used in developmental mathematics including traditional classroom, computer aided instruction and distance education methods.

This was followed by an examination of variables contributing to academic performance. The factors examined include cognitive entry skills and intelligence, affective characteristics (including math anxiety, locus of control and learning styles) and quality of instruction.

This research was designed to fill the gaps in the existing research in several areas. Many studies have compared performance in different pedagogical methodologies, but few have attempted to predict performance in these pedagogical methodologies based on individual student characteristics. By identifying developmental mathematics students who are most likely to succeed in a particular type of classroom setting, success rates could be improved. Likewise, many studies have been conducted which link the factors of math anxiety, locus of control and learning styles to achievement in mathematics.

However, past research has typically examined these factors in relationship to each other, or in relationship to a single pedagogical methodology. This research examined these affective factors for college level developmental mathematics students as they relate to academic performance and attrition in the traditional classroom, computer aided instruction in an on-campus setting and computer-aided instruction in a distance setting.

CHAPTER 3

METHODOLOGY

This study investigated possible predictors of student success in different modes of instruction in developmental mathematics. This chapter includes a description of the sample, the data collection procedures, variables and data analysis.

Research Sample

The research sample for this study consisted of students from the North Lake campus of the Dallas Community College District enrolled during the Spring 1999 semester. The sample was drawn from developmental mathematics classes and consisted of two parallel parts: Elementary Algebra (DMAT 091); and Intermediate Algebra (DMAT 093). Student and instructor participation was voluntary.

North Lake College has an "open door" admissions policy. Assessment is not used to determine admission except for students wishing to enroll in "special admissions" programs. Any person who has graduated from high school or who has earned a General Education Diploma (G.E.D.) may apply for admission. Individuals who do not have a high school diploma or G.E.D. may also apply for admission when they meet certain stipulations. Admitted students must present Texas Academic Skills Program (TASP) scores or take the college assessment program prior to registration (Dallas County Community College District, 1999c).

During the Spring 1999 semester, there were 6,828 credit students enrolled at North Lake College. Of these, 3,468 (50.8%) were male and 3,331 (48.8%) were female.

The student body of North Lake College is ethnically diverse. During the Fall 1998 semester, the student body was made up of 59.5% white non-Hispanic, 14.1% Hispanic, 31.1% African-American, 8.5% Asian/Pacific Islander, 4.1% non-resident alien and 0.7% American Indian (Dallas Community College District, 1999b).

Beginning in the fall of 1998 enrollment in credit courses in the Dallas Community College District was subject to the Texas Academic Skills Program (TASP) legislation which required students deficient in math, reading or writing skills to enroll in developmental courses. During the Fall 1998 semester, 30% of North Lake College students required remediation in mathematics, 40% required remediation in reading and 20% required remediation in writing (Dallas County Community College District, 1999a). Spring 1999 data on enrollment in remedial courses was unavailable from the Dallas County Community College District, but was assumed to be similar to the Fall 1998 data for the purposes of this study.

Table 1 shows that Elementary and Intermediate Algebra were each offered in three instructional formats. Students who signed up for an on-campus section of developmental mathematics had a choice of class times. It was decided that both day and evening sections of the on-campus portion of the sample should be included since these sections are typically filled with very different types of students. Day students tend to be traditional college students, recently graduated from high school. Night students, on the other hand, tend to be working adults who are returning to school during the evenings to further their careers.

Table 1

Times and Instructional Modes of Classes in the Research Sample

Time of day	Mode of Delivery
Beginning Algebra—DMAT 091	
Day	Traditional
Evening	Traditional
Day	Computer-based on campus
Evening	Computer-based on campus
N/A	Computer-based at a distance
Intermediate Algebra—DMAT 093	
Day	Traditional
Evening	Traditional
Day	Computer-based on campus
Evening	Computer-based on campus
N/A	Computer-based at a distance

There was no intelligence testing involved in this study. However, North Lake College made efforts to ensure that students had the necessary cognitive entrance skills to succeed in developmental mathematics classes. In each developmental mathematics class a "readiness test" was given during the first week of class to determine if the student had the prerequisite skills and knowledge necessary for the class in which they were enrolled. These tests were designed by a team of mathematics instructors at North Lake College, and had been in use for three years. They were basically shortened final exams for the preceding mathematics class. If the student does not get a high enough score on the readiness test, he or she was judged as not having the prerequisite knowledge necessary for success in the current class. The instructors advised these students of the situation and discussed the possibilities of placing the student in a more appropriate level of mathematics classes. These processes were carried out during the first two weeks of the semester, and during these two weeks, many students changed levels and sections (and teaching methodologies).

The samples from both Beginning and Intermediate Algebra consisted of students in one of three pedagogical modes. The first mode was a traditional delivery format where the students and instructor met twice per week throughout the semester at scheduled times in an on-campus setting. Progress through objectives, tests and assignments were determined prior to the course and were presented in the course syllabus. Attendance at scheduled class meeting times was mandatory. It was important that the traditional education students were included in this study as the control group in the prediction of achievement and dropout.

The second mode examined in this study was a self-paced, non-lecture format. Instructional delivery was computer-based in a lab of 25 Pentium-class PCs equipped with CD-ROM drives running Windows ’95 system software within a local area network. The software used was the Interactive Mathematics Series from Academic Systems, Inc. It included sound and graphics, as well as one-on-one student/teacher interactions during scheduled class times. The course pace was determined by the student, who could elect to complete required components of the course slower or faster than the normal pace of a lecture class. Attendance at scheduled class meeting times was mandatory.

The third instructional mode for students in developmental mathematics classes was the distance education format. The students who signed up for this instructional mode were provided with the same computer software as was used for the on-campus computer-based classes. The student were required to have off-campus access to at least a 75MHz Pentium-class personal computer equipped with a CD-ROM drive, 16 MB of RAM, 100MB free had drive space, Windows '95 or Windows '98 system software with an internet connection and Netscape Navigator 3.0 or MS Explorer 3.0 and a 14.4K modem. The class fee covered software license, textbooks and CD ROMs. The students were required to attend an on-campus orientation session at the beginning of the semester. The student determined the course pace, and communication with the instructor was through e-mail and telephone. The students who signed up for this format had the option of visiting the instructor on-campus during the semester, but this was not required.

Since the final exam for every developmental mathematics class at North Lake College was a departmental exam, all students within the same level (either Beginning or Intermediate Algebra) took the same final exam. Students in the computer-based classes (whether they were on-campus or at a distance) took the same progress tests during the semester. Students in traditional classes took progress exams created by their instructor. Although standardization of the individual progress tests was not possible within the traditionally taught classes, or between traditionally taught and computer-based classes, it was believed that they all tapped the same domain or content area. That is, all instructors were attempting to evaluate students at either the elementary or intermediate level of algebra knowledge. Because instructors could not be forced to use of the same progress exams, it was assumed that there was some degree of equivalence between the various exams.

The total sample size for this study consisted of 135 Beginning Algebra students and 113 Intermediate Algebra students. To accommodate sample size, and to assure that a full range of students was tested, data was gathered from multiple class sections of each course in each delivery mode of the on-campus classes in both the day and in the evening. The delivery mode that most limited the sample size was distance education. Only one section of Beginning Algebra and one section of Intermediate Algebra in the distance mode was offered. There were 29 students enrolled in the distance education Beginning Algebra class and 24 students enrolled in the distance education Intermediate Algebra class. Many more students enrolled in the on-campus CBI and traditionally taught classes.

To obtain a larger sample size, other DCCCD campuses were investigated. Only one other campus offered the CBI classes in an on-campus setting. This campus broke up the developmental math sequence into three rather than two classes. Although the on-line sections of the developmental math classes were offered by other campuses, one instructor taught all the distance students for a particular class regardless of the campus through which the student signed up for the class. For these reasons, it was determined that other campuses would not provide student groups equal to those at the North Lake campus.

Measures

Three primary instruments were used to conduct this research. The locus of control of each student was determined by the use of Rotter's Internal-External Locus of Control Scale. The students' level of math anxiety was measured using the Abbreviated Mathematics Anxiety Rating Scale (Alexander & Martray, 1989). Learning Style was measured using the 4MAT Learning Type Measure (McCarthy & St. Germain, 1998a). In addition, a short supplementary questionnaire was used to elicit demographic information. Copies of each of these instruments and the supplementary questionnaire may be found in Appendix C.

Locus of Control Scale

The Rotter Internal-External (I-E) Scale was used to assess locus of control. This scale measures the "individual differences in a generalized expectancy or belief in external control" (Rotter, 1966, p. 9). It consists of 29 paired statements, six of which were filler items to disguise the purpose of the test. Respondents chose the statement from each pair for which they held the strongest belief. A locus of control score was computed by summing the items that indicate an external locus of control (see scoring guide, Appendix D). Scores can range from 0 to 23, with high scores indicating an external locus of control and low scores indicating an internal locus of control.

Rotter (1966) reported test-retest reliability coefficients of $r = .60$ for males and $r=.83$ for females over a one-month interval. Reliability coefficients over a two-month interval were $r =.49$ for males and $r =.61$ for females. Rotter also found the instrument to display moderate internal consistency reliability coefficients ranging from .65 to .79.

Math Anxiety Measure

In 1989, Alexander and Martray proposed that the MARS could be reduced to a unidimensional subset and developed the Abbreviated Mathematics Anxiety Rating Scale (AMARS) which was not necessarily focused on statistics. They found three factors defining the dimensions of mathematics anxiety, defined through factor pattern coefficients, as being math test anxiety, numerical task anxiety and math course anxiety. Through a series of one-way analyses of variance, 25 items from the original 98-item MARS were found to have statistically significant differences. According to Alexander and Martray, (1989):

> Coefficient alpha was .96 for the fifteen items associated with Factor I (Math Test Anxiety), .86 for the five Factor II (Numerical Task Anxiety) items, and .84 for the five Factor III (Math Course Anxiety) items. These coefficients compare favorably with the .97 coefficient alpha reported by Richardson and Suinn (1972) for the full scale 98-item MARS (p. 147).

There are several other instruments available for measuring levels of math anxiety. Among them are Suinn's Math Anxiety Rating Scale (MARS), Fennema and Sherman's (1976) nine Mathematics Attitude Scales, and Plake and Parker's (1982) revised version of the MARS. These instruments were considered, however the Abbreviated Mathematics Anxiety Rating Scale (AMARS) by Alexander and Martray (1989) was chosen as the measure for mathematics anxiety in this study. The AMARS was an appropriate choice for four reasons. First, it is made up of only 25 items, as compared to 98 items on the original MARS. The shorter length made this instrument desirable since the subjects were asked to voluntarily complete several scales. Second, the AMARS is not focused on statistics, as is Plake and Parker's (1982) revised version of the MARS. Third, the AMARS is not designed for high school subjects, as is Fennema and Sherman's (1976) Mathematics Attitude Scales. Fourth and finally, the three distinct aspects of mathematics anxiety measured by the AMARS were investigated individually in this study as having possible predictive value.

<u>Learning Styles Measure</u>

The 4MAT Learning Type Measure (LTM) (McCarthy & St. Germain, 1998a) measures the strength of four types of learning: those who perceive information concretely and process it reflectively are termed imaginative learners and are designated as Type 1 learners; those who perceive information abstractly and process it reflectively are termed analytic learners and are designated as Type 2 learners; those who perceive information abstractly and process it actively are termed common sense learners and are designated as Type 3 learners; and those who perceive information concretely and process it actively are termed dynamic learners and are designated as Type 4. The LTM is based on the work of Jung, Kolb, Lewin, Myers, Bogen and McCarthy.

> Specifically reflected in the LTM are (1) situational adaptations of Jung's constructs of feeling, thinking, sensing, intuition, extroversion and introversion. (2) behaviors modeled after Kolb's constructs of concrete experiential, reflective, abstract and active learners, (3) representations of hemisphericity drawn from Bogen, and (4) McCarthy's field work. (McCarthy & St. Germain, 1998b, p. 8-9).

Since brain hemisphericity was not considered in this research, the portion of the LTM which measures hemisphericity (Part B) was not examined.

Part A of the LTM, which was used in this research, contains 15 items, each with four response choices. Respondents were asked to rank each choice from 4 (most like you) to 1 (least like you). The choices were keyed to represent learning type (McCarthy & St. Germain, 1998a).

In considering the construct validity for learning type, which is to determine if one learning type is distinguishable from the others, 390 people were administered the LTM. Only 10 people had a tie between learning types. In addition, 70% of the respondents had differences between their two most highly favored learning types (McCarthy & St. Germain, 1998b).

Concurrent validity was examined by comparing the LTM to the Kolb Learning Style Inventory (LSI). Using a contingency table analysis, it was found that there was a 61.1% agreement (chi-square=137.4286, df=9, $p<.0001$; Cramer's V=.51163, contingency coefficient=.66323) between the two measures. In addition the LTM was compared to the Myers Briggs Type Indicator (MBTI) and significant relationships were found between the Feeling score on the MBTI and the Learning Type 1 score, the Introvert, Thinking, and Judging scores on the MBTI and the Learning Type 2 score, the Sensing score on the MBTI and the Learning Type 3 score, and the Extrovert, Intuitive and Perceiving score on the MBTI and the Learning Type 4 score (McCarthy & St. Germain, 1998b).

Reliability of Part A of the LTM was also examined among the same 390 subjects. Internal consistency, as measured by the Cronbach alpha statistic was: Learning Type One=0.853; Learning Type Two=0.835; Learning Type Three=0.767; and Learning

Type Four=0.885. In a test-retest, the coefficient of stability was found to be .71 which is an acceptable level of stability (McCarthy & St. Germain, 1998b).

The LTM was chosen as the instrument to measure the learning style component of this study for several reasons. It had acceptable levels of validity and reliability. It combined several theoretical constructs that could prove significant in this study. With 15 questions, it also was relatively short in length and since this study involved multiple instruments it was thought that no single instrument should require too much of the subjects' time.

Supplemental Questionnaire

A supplemental questionnaire (see Appendix C) was used to collect demographic information. The demographic information which was gathered included gender, age, time since last mathematics course, previous math classes, previous attempted math classes, previous instructional formats, employment status, school funding methods, ethnicity and native language. The information that was gathered from this instrument was used to describe the characteristics of the sample.

Data Collection Procedures

An application for Approval of Investigation Involving Human Subjects was submitted to the University of North Texas Institutional Review Board (IRB) and was approved. Approval was also applied for and received by from the President of North Lake College. No data was collected prior to receiving approval from both institutions (see Appendix E).

The researcher met with the dean of the Math, Natural Science/Sport Science Division at North Lake College to obtain support for the study. Arrangements were made with the dean for the distribution and collection of faculty surveys.

During the first week of classes, many students at North Lake College were still in the process of registering and changing sections. Some students changed the level of developmental mathematics class they had registered for based on the results of the departmental “readiness tests” described in the first section of this chapter. In addition, the dean of the division did not want the instructors burdened with a research project during the first month of classes. For these reasons, data collection did not begin until four weeks after classes started.

Instructors of on-campus classes who agreed to participate distributed the research surveys in their classes and instructed the students to return the surveys the next class period. Students first completed an informed consent agreement. Next they completed a short demographic survey, which was used for descriptive statistical analysis. Students then completed the Rotter’s Internal-External Locus of Control Scale, the Abbreviated Mathematics Anxiety Scale and the Learning Type Measure. After two weeks, the researcher visited the classrooms where responses had not been received to encourage student participation and return of the surveys.

Research materials were mailed directly to the students in the distance education sections during the fourth class week. They were provided with a stamped and addressed envelope and asked to mail the instruments back to the researcher. Students who did not respond were sent post cards, emailed and sent an additional copy of the research materials over the next four weeks until an acceptable percentage of returned research materials was obtained by the researcher.

Subjects then completed the semester. At the end of the semester, the students were administered a final exam. The final exams for both Beginning Algebra and Intermediate Algebra were departmental exams. They were created by a team of developmental mathematics instructors, and have been used for several years. For these reasons, they were considered valid measures of progress for the purposes of this study.

The final exam as well as the course grade for Beginning Algebra and Intermediate Algebra classes were analyzed as the achievement measures. Both of these were examined because if students had high levels of mathematics anxiety, it seemed reasonable that final exam score might not be a good indicator of achievement.

In addition, students who dropped the course and students who finished the semester with an incomplete were tracked to see whether their attrition patterns followed any predictable trends based on locus of control, mathematics anxiety or learning style.

Since there were no gross non-normal distributions, scores for both the final grade and the final exam they were reported as percentages to provide the best possible distribution of results for analysis.

At the end of the semester, all students who indicated (on the Request for Results form, Appendix C) that they wanted a copy of their results on the three instruments were provided with them. The on-campus students received their results during the last class week or during the final exam period. Results were mailed to the distance education students to arrive during the final exam week. During the semester, instructors were not provided with individual or aggregate results from any of the measures used in the study.

Data Analysis

All data gathered was reported in the aggregate form to protect anonymity. The first set of analysis was descriptive in nature and used the results from the supplemental demographic questionnaire to describe the characteristics of the sample. In addition, a summary of results from each other survey instruments was provided.

Next, the equality of groups in the study was examined using a multivariate analysis of variance (MANOVA) to answer research questions one (Are there differences in achievement as measured by final grade between developmental mathematics classes taught in the traditional format, the computer-aided in the classroom format, and the computer-aided at a distance format?), and two (Are there differences in achievement as measured by final exam score between developmental mathematics classes taught in the traditional format, the computer-based in the classroom format, and the computer-based at a distance format?) Each question was analyzed twice (once using the Beginning Algebra sample and once using the Intermediate Algebra sample). In each case, there were four independent variables (instructional method (with three categories of traditional instruction, on-campus computer-managed instruction, and computer-based instruction at a distance), locus of control, learning style and math anxiety) and two dependent variables (final course grade (on a scale of 0 - 100%), and final exam grade). The overall F statistic told us if there was any difference within any of the dependent measures. MANOVA is used to determine whether several groups differ on more than one dependent variable (Borg & Gall, 1989). MANOVA separates the unique contribution that each dependent variable makes to understanding group differences so that differences are not mingled between variables (Salkind, 1991). In addition, MANOVA is used rather than multiple pairwise t-tests to protect against an artificially inflated Type I error. For these reasons, MANOVA was used as an appropriate methodology for this study.

In research question three (Are there differences in attrition between developmental mathematics classes taught in the traditional format, the computer-based in the classroom format, and the computer-aided at a distance format?) the dependent variable of attrition was dichotomous. Because of this, chi square analysis was used to examine this relationship separately for the parallel sample groups (Beginning Algebra and Intermediate Algebra).

Research questions four (Can achievement as measured by final grade be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?), five (Can achievement as measured by final exam score be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?) and six (Can attrition be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?) were analyzed through regression analysis to examine the effect of the independent variables (instructional method, locus of control, learning style and mathematics anxiety) on predicting the dependent variables (achievement as measured by final grade (on a scale of 0 – 100%), achievement as measured by final exam score and attrition within each instructional method (traditional classroom, on-campus computer-based and computer-based at a distance). Logistic regression was used for attrition across the three different methods of instruction and normal regression was used for final exam and final course grade across the three different methods of instruction for each sample group.

Regression is a powerful analytic tool. The greatest virtue of regression is "its capacity to mirror, with high fidelity, the complexity of the relationships that characterize the behavioral sciences" (Cohen & Cohen, 1975, p. 7). When one considers the set of variables that influence academic achievement, a multiplicity of factors exists. After each factor is examined separately, multiple regression is an efficient strategy for studying multiple factors. In addition, multiple regression is capable of assessing unique variance and assigning partial regression coefficients. The effects of any research factor can be partialled from the effects of any desired set of other factors (Cohen & Cohen, 1975). Although regression can be used equally well in experimental or non-experimental research (Kerlinger & Pedhazur, 1973, p. 3), its partialling abilities make it particularly useful for nonexperimental studies.

Research question seven (Are age, ethnicity, gender, previous mathematics courses, previous attempts and employment status related to final exam grade, final grade (on a scale from 0 – 100%) was examined in an exploratory manner with correlational statistics.

Summary

This research project investigated possible predictors of student success, measured by final grade, final exam and attrition, in different modes of instruction in developmental mathematics. The modes of instruction were traditional classroom, computer aided instruction in an on-campus setting, and computer-based instruction in a distance education setting. The predictors were locus of control, mathematics anxiety and learning style. Demographic information was also analyzed using descriptive techniques.

CHAPTER 4

DATA ANALYSIS AND DISCUSSION OF RESULTS

Introduction

The purpose of this study was to investigate the relationship between individual student differences and academic success (as measured by final exam score and final class grade) in three pedagogical methods (traditional classroom, computer-aided in an on-campus setting, and computer-aided in a distance education setting) for developmental mathematics classes at the community college level. Locus of control, math anxiety and learning style were the specific individual differences that were examined in this study.

A secondary purpose was exploratory and examined whether other student characteristics (such as age, ethnicity, gender, previous mathematics courses, previous attempts, and employment status) predicted the academic success of individual students in the three different instructional methods (traditional, computer-based on campus and computer-based at a distance) of developmental mathematics.

For both the Beginning and Intermediate Algebra groups, the study used the following research questions:

1. Are there differences in achievement as measured by final grade (on a scale from 0 - 100%) between developmental mathematics classes taught in the traditional format, the computer-aided in the classroom format, and the computer-aided at a distance format?

2. Are there differences in achievement as measured by final exam score between developmental mathematics classes taught in the traditional format, the computer-based in the classroom format, and the computer-based at a distance format?

3. Are there differences in attrition (persisted vs. dropped out) between developmental mathematics classes taught in the traditional format, the computer aided in the classroom format, and the computer-aided at a distance format?

4. Can achievement, as measured by final grade (on a scale from 0 - 100%) be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

5. Can achievement, as measured by final exam score be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

6. Can attrition (persisted vs. dropped out) be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

7. Are age, ethnicity, gender, previous mathematics courses, previous attempts and employment status related to final exam grade, final grade (on a scale from 0 - 100%) and attrition?

The first three questions looked at whether there were differences in achievement between the three formats of instruction. The next three questions examined whether there were predictable differences in achievement between the three groups. The last question examined whether demographic characteristics were related to achievement.

This chapter is organized into six sections. The first section is entitled Survey Findings and provides an assessment of the number of surveys distributed, their respective return rates and descriptive statistics for both Beginning and Intermediate Algebra. The second section is entitled Demographic Characteristics of the Sample and examines the results of the demographic portion of the survey. The third section is concerned with research questions one and two and is entitled Equality of Groups. The remaining three sections provide specific findings for the study's remaining five research questions. The sections are titled Differences in Attrition Between Instructional Formats, Prediction of Final Grade, Final Exam Score and Attrition, and Demographic Relationships.

Survey Findings

There were two parallel sample groups in this study. These were the Beginning Algebra group and the Intermediate Algebra group. This section examines the number of surveys distributed, their respective return rates and descriptive statistics for each of the sample groups.

Beginning Algebra

A total of 247 surveys were distributed to the Beginning Algebra group. There were 85 distributed to traditionally taught students, 133 distributed to the students enrolled in computer-based instruction on campus and 29 distributed to the students enrolled in computer-based instruction at a distance. After four weeks the researcher had received 135 survey responses. Of these, the traditionally taught students returned 47 surveys. The computer-based on campus sections returned 64 surveys and the computer-based at a distance section returned 24 surveys. Three of the surveys in the traditionally taught group, three of the surveys in the CBI on-campus group and one of the surveys in the Distance Education group were returned with the learning style instrument incorrectly completed and were not used for further analysis which involved learning style. Overall, there were a total of 135 surveys used in the analysis of the Beginning Algebra group, excluding those involving learning style, for a return rate of 55%. There were 128 surveys used in the analyses involving learning style for an adjusted return rate of 52%. Refer to Table 2 for a complete illustration of the number of surveys distributed and returned for the Beginning Algebra group.

Table 2

Total Surveys Distributed and Usable Surveys Returned for Beginning Algebra

Method	Distributed	Returned	Return Rate	LTM Incomplete	LTM Complete	Adjusted Return Rate
Traditional	85	47	55%	3	44	52%
CBI	133	64	47%	3	61	46%
Distance	29	24	83%	1	23	79%
Total	247	135	55%	7	128	52%

Prior to detailed analysis, the rates of course completion and attrition were examined for each method. These rates are illustrated in Table 3. In the Beginning

Algebra group, one third of the students dropped the class, while two thirds received a final grade. The distance education group had the highest percentage of attrition (50%), followed by the CBI group where 40.6% of the subjects dropped the course. The traditionally taught classes had the lowest attrition rate at 14.9%.

Table 3

Beginning Algebra Completion

	Dropped Frequency	Dropped Percentage	Persisted	Persisted Percentage	Total	Percentage of Total
Traditional	7	14.9%	40	85.1%	47	34.8%
CBI	26	40.6%	38	59.4%	64	47.4%
Distance	12	50%	12	50%	24	17.8%
Total	45	33.3%	90	66.6%	135	100%

Of the 90 students who received a final grade, about 45% took the final examination for Beginning Algebra and 55% did not take the final examination. The traditionally taught students took the final exam more frequently than did the CBI students or the distance education students. While students could fail the course whether they took the final examination of not, all students who elected not to take the final examination for Beginning Algebra failed the course. Table 4 details these statistics.

Table 4

<u>Final Examination Status for Beginning Algebra</u>

Final Exam Status		Traditional	CBI	Distance	Total
Took final exam	Frequency	28	23	10	61
	% within method	59.6%	35.9%	41.7%	45.2%
Did not take final exam	Frequency	19	41	14	74
	% within method	40.4%	64.1%	58.3%	54.8%
Total	Frequency	47	64	24	135
	% of Total	34.8%	47.4%	17.8%	100%

Next the mean scores for all 90 students who persisted and received a final grade in the course were calculated. This group of subjects included those who did not take the final examination and failed the course. Overall, the mean for the final grade percentage for students who persisted was 63.43%. Table 5 provides a detailed analysis of the mean scores.

The mean scores for final grade and final examination were calculated for the 61 students who took the final examination. In this analysis, the mean final grade was 77.57% reflecting the deletion of the 29 students who persisted and received a final grade in the class but did not take the final examination and failed. The mean score for the final examination was 59.43%. Table 6 provides greater detail for the final grade and final examination mean scores for each group.

Table 5

Beginning Algebra Mean Scores for Final Grade Including Non-Final Exam Takers

Method	N	Final Grade Mean Score	Standard Deviation
Traditional	40	59.68	25.62
CBI	38	66.45	25.82
Distance Ed	12	66.42	21.99
Total	90	63.43	25.22

Table 6

Beginning Algebra Mean Scores for Final Grade and Final Exam Excluding Subjects Not Taking Final Exam

Method	N	Final Grade Mean Score	Standard Deviation	Final Exam Mean Score	Standard Deviation
Traditional	28	72.32	17.17	56.75	28.57
CBI	23	85.30	4.47	60.13	15.39
Distance Education	10	74.50	9.91	65.30	19.14
Total	61	77.57	13.86	59.43	22.77

Next, the Locus of Control scores for the Beginning Algebra group were analyzed. As dictated by Rotter's scoring guidelines (see Appendix) subjects who received a score of 10 or less on Rotter's Locus of Control Scale were categorized as having an internal locus of control, while those who received a score of 11 or more were categorized as having an external locus of control. Overall, 62.2% of the Beginning Algebra students had an internal locus of control and 37.8% had an external locus of control. Detailed findings for locus of control are found in Table 7.

Table 7

Locus of Control Results for Beginning Algebra

Method	Internal	Percent within Method	External	Percent within Method	Total	Percent Of Total
Traditional	31	66.0	16	34.0	47	34.8
CBI	38	59.4	26	40.6	64	47.4
Distance	15	62.5	9	37.5	24	17.8
Total	84	62.2	51	37.8	135	100

Results for the 4MAT Learning Type Measure for the Beginning Algebra group were examined. Subjects were categorized into one of four quadrants based on what quadrant was dominant, as directed in the scoring guidelines for the LTM Learning Type Measure. Subjects who had tying scores in two or more categories were labeled as "No Single Type." Table 8 gives detailed results for the Learning Type Measure, and shows that about one quarter of the subjects had learning styles that were in each of quadrants one, two and three. Only about half as many subjects (about 13%) scored as having a learning style predominantly in quadrant four, and about 10% of the subjects had no single learning type.

Table 8

Learning Type Results for Beginning Algebra

Learning Type		Traditional	CBI	Distance	Total
Quadrant 1	Frequency	13	17	4	34
	% within method	29.5%	27.9%	17.4%	26.6%
Quadrant 2	Frequency	12	13	4	29
	% within method	27.3%	21.3%	3.1%	22.7%
Quadrant 3	Frequency	7	19	10	36
	% within method	15.9%	31.1%	43.5%	28.1%
Quadrant 4	Frequency	6	7	4	17
	% within method	13.6%	8.2%	4.3%	13.3%
No single type	Frequency	6	5	1	12
	% within method	13.6%	8.2%	4.3%	9.4%
Total	Frequency	44	61	23	128
	% of total	34.4%	47.7%	18.0%	100%

Finally, the results from the Abbreviated Mathematics Anxiety Rating Scale were examined. For simplicity, the results from the scale (which can range from 1 to 5) were categorized into low, medium and high levels of anxiety. Those subjects who scored from 1 to 1.67 were categorized as having a low level of mathematics anxiety. Subjects who scored from 1.68 to 3.33 were categorized as having a moderate level of mathematics anxiety and subjects who scored from 3.33 to 5.0 were categorized as having a high level of mathematics anxiety. About three fifths of the 135 subjects scored in the moderate level of mathematics anxiety. About one fifth of the of the respondents' scores fell each of the remaining categories of mathematics anxiety (low and high). Table 9 provides an expanded view of these results.

Table 9

Overall Mathematics Anxiety Results for Beginning Algebra

Level of Anxiety		Traditional	CBI	Distance	Total
Low	Frequency	10	10	4	24
	% within method	21.3%	15.6%	16.7%	17.8%
Moderate	Frequency	25	41	18	84
	% within method	53.2%	64.1%	75.0%	62.2%
High	Frequency	12	13	2	27
	% within method	25.5%	20.3%	8.3%	20%
Total	Frequency	47	64	24	135
	% of total	34.8%	47.4%	17.8%	100%

Intermediate Algebra

A total of 173 surveys were distributed to the Intermediate Algebra group. There were 76 distributed to traditionally taught students, 73 distributed to the students enrolled in computer-based instruction on campus and 24 distributed to the students enrolled in computer-based instruction at a distance. After four weeks the researcher had received 113 survey responses. Of these, the traditionally taught students returned 46 surveys. The computer-based on campus sections returned 49 surveys and the computer-based at a distance section returned 18 surveys. Two of the surveys in the traditionally taught group, and four of the surveys in the CBI on-campus group were returned were returned with the learning style instrument incorrectly completed and were not used for analysis that involved learning style. Overall, there were a total of 113 surveys used in the analysis of the Intermediate Algebra group, excluding those involving learning style, for a return rate of 65%. There were 107 surveys used in the analyses involving learning style for an adjusted return rate of 62%. Refer to Table 10 for a complete illustration of the number of surveys distributed and returned for the Intermediate Algebra group.

Table 10

Total Surveys Distributed and Usable Surveys Returned for Intermediate Algebra

Method	Distributed	Returned	Return Rate	LTM Incomplete	Usable	Adjusted Return
Traditional	76	46	61%	2	44	58%
CBI	73	49	67%	4	45	62%
Distance	24	18	75%	0	18	76%
Total	173	113	65%	6	107	62%

Prior to detailed analysis, the rates of course completion and attrition were examined for each method. These rates are illustrated in Table 11. The distance education group had the highest percentage of attrition, followed by the CBI group. The traditionally taught classes had the lowest attrition rate. Overall, 43.4% of the subjects dropped while 56.5% of the subjects persisted and received a final grade for Intermediate Algebra.

Table 11

Intermediate Algebra Completion

Method	Dropped Frequency	Dropped Percentage	Persisted Frequency	Persisted Percentage	Total	Percentage of Total
Traditional	17	37.0%	29	63.0%	46	43.4%
CBI	20	40.8%	29	59.2%	49	56.6%
Distance	12	66.7%	6	33.3%	18	15.9%
Total	49	43.4%	64	56.6%	113	100%

Of the 64 students who received a final grade, about 68% took the final examination for Intermediate Algebra and 32% did not take the final examination. Table 12 details these statistics. The traditionally taught students took the final exam more frequently than did the CBI students or the distance education students. While students could fail the course whether they took the final examination or not, all students who elected not to take the final examination for Intermediate Algebra failed the course.

Next the mean scores for all 59 students who persisted and received a final grade in the course were calculated. This group of subjects included those who did not take the final examination and failed the course. The overall mean final grade percentage for the students who persisted was 66.79% with a standard deviation of 24.38. Table 13 provides a detailed analysis of the mean scores.

Table 12

Final Examination Status for Intermediate Algebra

Final Exam Status		Traditional	CBI	Distance	Total
Took final exam	Frequency	24	17	4	68
	% within method	52.5%	34.7%	22.2%	60.2%
Did not take final exam	Frequency	22	32	14	45
	% within method	47.8%	65.3%	77.8%	39.8%
Total	Frequency	46	49	18	113
	% of Total	40.7%	43.4%	15.9%	100%

Table 13

Intermediate Algebra Mean Scores for Final Grade Including Non-Final Exam Takers

Method	N	Final Grade Mean Score	Standard Deviation
Traditional	29	67.97	24.84
CBI	24	67.94	21.81
Distance Ed	6	56.50	33.32
Total	59	66.79	24.38

The mean scores for final grade and final examination were calculated for the 45 students who took the final examination. Table 14 provides detailed results for the final grade and final examination mean scores for each group. In this analysis, the mean final grade increased in comparison to the mean scores that included those students who did not take the final examination as shown in Table 13. This increase in scores reflected the deletion of the 14 students who persisted and received a final grade in the class but did not take the final examination and thus failed the course.

Table 14

Intermediate Algebra Mean Scores for Final Grade and Final Exam Excluding Subjects Not Taking Final Exam

Method	N	Final Grade Mean Score	Standard Deviation	Final Exam Mean Score	Standard Deviation
Traditional	24	76.29	16.01	60.04	24.84
CBI	17	80.32	6.62	42.59	21.81
Distance Education	4	77.25	10.56	56.75	33.32
Total	45	77.90	12.70	53.16	24.38

Next, the Locus of Control scores for the Intermediate Algebra group were analyzed. As dictated by Rotter's scoring guidelines (see Appendix) subjects who received a score of 10 or less on Rotter's Locus of Control Scale were categorized as having an internal locus of control, while those who received a score of 11 or more were categorized as having an external locus of control. Overall, a little under two thirds of the Intermediate Algebra students had an internal locus of control and a few over one third had an external locus of control. Detailed findings for locus of control for the Intermediate Algebra group are found in Table 15.

Table 15

<u>Locus of Control Results for Intermediate Algebra</u>

Method	Internal	Percent within Method	External	Percent within Method	Total	Percent of Total
Traditional	30	65.2%	16	34.8%	46	40.7%
CBI	31	63.3%	18	36.7%	49	43.4%
Distance	9	50.0%	9	50.0%	18	15.9%
Total	70	61.9%	43	38.1%	113	100%

Results for the 4MAT Learning Type Measure for the Intermediate Algebra group were examined. Subjects were categorized into one of four quadrants based on what quadrant was dominant, as directed in the scoring guidelines for the LTM Learning Type Measure. Subjects who had tying scores in two or more categories were labeled as being in "no single type". Table 16 gives detailed results for the Learning Type Measure for the Intermediate Algebra group, and shows that overall about 29% of the subjects had a learning style that was predominantly in quadrant one, 22% were predominantly in quadrant two, 29% were predominantly in quadrant three, 16% were predominantly in quadrant four, and 5% had no single learning type.

Table 16

Learning Type Results for Intermediate Algebra

Learning Type		Traditional	CBI	Distance	Total
Quadrant 1	Frequency	15	13	3	31
	% within method	34.1%	28.9%	16.7%	29%
Quadrant 2	Frequency	8	10	5	23
	% within method	18.2%	22.2%	27.8%	21.5%
Quadrant 3	Frequency	12	13	6	31
	% within method	27.3%	28.9%	33.3%	29%
Quadrant 4	Frequency	9	5	3	17
	% within method	20.5%	11.1%	16.7%	15.9%
No single type	Frequency	0	4	1	5
	% within method	0%	8.9%	5.6%	4.7%
Total	Frequency	44	45	18	107
	% of total	41.12%	42.06%	16.82%	100%

Finally, the results from the Abbreviated Mathematics Anxiety Rating Scale were examined. For simplicity in presenting these results, the results from the scale (which can range from 1 to 5) were categorized into low, medium and high levels of anxiety. Those subjects who scored from 1 to 1.67 were categorized as having a low level of mathematics anxiety. Subjects who scored from 1.68 to 3.33 were categorized as having a moderate level of mathematics anxiety and subjects who scored from 3.33 to 5.0 were categorized as having a high level of mathematics anxiety. The majority of the 113 subjects scored in the moderate level of mathematics anxiety. 14.2% of the respondents' scores fell in the low level of mathematics anxiety while 17.7% of the scores fell in the in the high level. Table 17 provides an expanded view of these results.

Table 17

Overall Mathematics Anxiety Results for Intermediate Algebra

Level of Anxiety		Traditional	CBI	Distance	Total
Low	Frequency	7	3	6	16
	% within method	15.2%	6.1%	33.3%	14.2%
Medium	Frequency	31	38	8	77
	% within method	67.4%	77.6%	44.4%	68.1%
High	Frequency	8	8	4	20
	% within method	17.4%	16.3%	22.2%	17.7%
Total	Frequency	46	49	18	113
	% of total	40.7%	43.4%	15.9%	100%

Demographic Characteristics of the Sample

The demographic portion of the survey (see Appendix C) asked participants to identify their gender and age. The respondents were also asked to identify whether or not they were employed. If they were employed they were asked to identify how many hours per week they worked. In addition the respondents were asked to identify the manner in which they paid for college expenses, their ethnicity and whether or not English was their native language.

Four questions were asked about the respondents' mathematics experience. They were asked how long it had been since they had taken a mathematics course, and whether they took the developmental math class previous to the class they were currently enrolled in or tested directly into their present class. In addition they were asked to identify how many times they had previously attempted but not successfully completed their current mathematics class, and the instructional formats in which they had previously taken math classes. Response summaries for both the Beginning Algebra and the Intermediate Algebra groups are reviewed below.

Beginning Algebra

The 135 respondents in the Beginning Algebra group were comprised of more females than males. 48 (35.6%) of the Beginning Algebra respondents were male, while 87 (64.6%) were female.

The age of the Beginning Algebra students ranged from 16 to 52. Almost half of the respondents were in the 20-29 year age group. It is interesting to note that 71.1% of the respondents were 29 years of age and below, showing that the Beginning Algebra classes were made up mostly of younger students, as can be expected in a Community College setting. However, over a quarter of the students were aged 30 and above. Table 18 provides detailed results for the Beginning Algebra students' age categories.

Of the 135 Beginning Algebra students 118 (87.4%) were employed, while 17 (12.6%) were not employed. Of the 118 Beginning Algebra students who were employed, the majority worked 40 or more hours per week. Table 19 provides a detailed review of work hours per week for the employed Beginning Algebra respondents.

Table 18

Age of Beginning Algebra Respondents

Age	Frequency	Percent
16-19	30	22.2
20-29	66	48.9
30-39	20	14.8
40-49	16	11.9
50-59	3	2.2

Table 19

Work Hours Per Week for Beginning Algebra Students

Hours Per Week	Frequency	Percent
Less than 10	1	0.8
10-19	4	3.4
20-29	22	18.6
30-39	23	19.5
40 or more	68	57.6
Total	118	99.9

The majority of the Beginning Algebra respondents (56.3%) paid for college expenses themselves. It is interesting to note that this percentage is very close to the percentage of students (57.6%) who worked 40 or more hours per week as shown in Table 19. One fifth of the respondents had parents who paid for their education, 5.2% had scholarships which paid for their education and 18.5% of the students had either a combination of methods, or another method (such as an employer tuition reimbursement program) paying for their educational expenses. Table 20 provides a detailed results of the manner in which Beginning Algebra students paid for college expenses.

Table 20

Manner College Expenses Were Paid for by Beginning Algebra Students

How Paid	Frequency	Percent
Self	76	56.3%
Parent	27	20.0%
Scholarship	7	5.2%
Other	25	18.5%
Total	135	100%

The 135 Beginning Algebra students were requested to report their ethnicity and whether English was their native language. 78 (57.8%) of the respondents were Caucasian. 24 (17.8%) of the respondents were Hispanic, 17 (12.6%) were African American, and 3 (2.2%) were Asian. 13 (9.6%) of the respondents either listed more than one ethnicity, or were of another ethnicity (such as American Indian). English was the native language for 117 (86.7%) of the Beginning Algebra respondents, while English was not the native language for the remaining 18 (13.3%).

The first of the questions dealing with mathematics experience was concerned with the length of time since the respondent's last math class. The majority of the Beginning Algebra respondents had a mathematics class during the previous year. It is interesting to note that the next most frequent response to this question was that the student had not had a mathematics class for over three years (36.2%). Table 21 provides a more detailed analysis of the results.

Table 21

Length of Time Since Last Math Class for Beginning Algebra Students

Length of Time	Frequency	Percent
< 1 year	70	51.9%
1 to 2 years	9	6.7%
2 to 3 years	7	5.2%
> 3 years	49	36.2%
Total	135	100%

The next question examined was the respondent's method of entrance into the class. 77 (57%) of the respondents took the Developmental Mathematics class prior to Beginning Algebra. 58 (43%) of the respondents tested directly into Beginning Algebra. Respondents were also asked to share the number of unsuccessful attempts they had previously had in Beginning Algebra. 91 (71.1%) of the respondents indicated that they had never previously attempted Beginning Algebra. 27 (20%) of the respondents had unsuccessfully attempted Beginning Algebra one time, 9 (6.7%) had unsuccessfully attempted it two times, and only 3 (2.3%) had unsuccessfully attempted Beginning Algebra three or more times.

Respondents were also asked about the formats in which they had previously taken mathematics classes. Almost three quarters of the Beginning Algebra respondents indicated that they had taken their previous mathematics classes in a traditional lecture format. 11.9% of the respondents had taken computer-based on-campus mathematics classes and 7.4% of the students had taken a mathematics course via distance education. 8.9% of the respondents had taken a mathematics course in a self-paced format, which at North Lake College consists of the student buying a book and working independently through objectives with a tutor in the room to answer questions. Only one respondent indicated that they had taken mathematics classes in another format. Table 22 provides specific details about the response to this question.

Table 22

Previous Instructional Formats for Beginning Algebra Students

Instructional Format	Frequency	Percent
Traditional on-campus	96	71.1
Computer-based on-campus	16	11.9
Distance Education	10	7.4
Self Paced	12	8.9
Other	1	0.7
Total	135	100

Intermediate Algebra

The Intermediate Algebra group was comprised of more females than males. 84 (74.3%) of the Beginning Algebra respondents were female, while 29 (25.7%) were male.

The ages of the Intermediate Algebra students ranged from 15 to 54. The greatest percentage of respondents fell in the 20-29 year age group. It is interesting to note that

78.7% of the respondents were 29 years of age and below, showing that the Intermediate Algebra classes were made up mostly of younger students, as can be expected in a Community College setting. However, just under a fifth of the students were aged 30 and above. Table 23 provides detailed results for the Intermediate Algebra students' age categories.

Table 23

Age of Intermediate Algebra Respondents

Age	Frequency	Percent
15-19	23	20.4
20-29	66	58.3
30-39	15	13.3
40-49	6	5.3
50-59	1	0.9
Missing	2	1.8
Total	113	100

Of the 113 Intermediate Algebra students 97 (85.8%) were employed, while 15 (13.3%) were not employed. One survey was missing age data. Of the 97 Intermediate Algebra students who were employed, the majority worked 40 or more hours per week. Table 24 provides a detailed review of work hours per week for Intermediate Algebra students.

Table 24

Work Hours Per Week of Intermediate Algebra Students

Hours Per Week	Frequency	Percent
Less than 10	2	2.1
10-19	11	11.3
20-29	20	20.6
30-39	13	13.4
40 or more	51	52.6
Total	97	100

Almost half of the Intermediate Algebra respondents (46.9%) paid for college expenses themselves. It is interesting to note that this percentage is very close to the percentage of students (52.6%) who worked 40 or more hours per week shown in Table 24. 24.8% of the respondents had parents who paid for their education, 6.2% had scholarships which paid for their education and 22.1% of the students had either a combination of methods, or another method (such as an employer tuition reimbursement program) paying for their educational expenses. Table 25 provides a more detailed illustration of the manner in which Intermediate Algebra students paid for college expenses.

Table 25

Manner College Expenses Were Paid for by Intermediate Algebra Students

How Paid	Frequency	Percent
Self	53	46.9
Parent	28	24.8
Scholarship	7	6.2
Other	25	22.1
Total	113	100

The 113 Intermediate Algebra students were requested to report their ethnicity and whether English was their native language. 67 (59.3%) of the respondents were Caucasian. 16 (14.2%) of the respondents were Hispanic, 10 (8.8%) were African American, and 9 (8%) were Asian. 11 (9.7%) of the respondents either listed more than one ethnicity, or were of another ethnicity (such as American Indian). English was the native language for 92 (81.4%) of the Intermediate Algebra respondents, while English was not the native language for 20 (17.7%). There was one survey respondent who did not answer the question about whether or not English was their native language.

The first of the questions dealing with mathematics experience examined dealt with the length of time since the last math class. The majority of the Intermediate Algebra respondents had a mathematics class during the previous year. It is interesting to note that the next most frequent response to this question was that the student had not had a mathematics class for over three years (17.4%). Table 26 provides a more detailed analysis of the results.

Table 26

Length of Time Since Last Math Class for Intermediate Algebra Students

Length of Time	Frequency	Percent
< 1 year	66	58.4
1 to 2 years	18	15.9
2 to 3 years	8	7.1
> 3 years	20	17.7
Missing	1	.9
Total	113	100

The next question examined was the respondent's method of entrance into the class. 68 (60.2%) of the respondents took the Developmental Mathematics class prior to Intermediate Algebra. 43 (38.1%) of the respondents tested directly into Intermediate Algebra. Two respondents did not answer the question. Respondents were also asked to share the number of unsuccessful attempts they had previously had in Intermediate Algebra. 80 (61.1%) of the respondents indicated that they had never previously attempted Intermediate Algebra. 34 (30.1%) of the respondents had unsuccessfully attempted Intermediate Algebra one time, 6 (5.3%) had unsuccessfully attempted it two times, and only 3 (2.7%) had unsuccessfully attempted Intermediate Algebra three times. One respondent did not answer the question.

Respondents were also asked about the formats in which they had previously taken mathematics classes. Almost three quarters of the Intermediate Algebra respondents indicated that they had taken their previous mathematics classes in a traditional lecture format. 15% of the respondents had taken computer-based on-campus mathematics classes and 1.8% of the students had taken a mathematics course via distance education. 10.6% of the respondents had taken a mathematics course in a self paced format, which at North Lake College consists of the student buying a book and working independently through objectives with a tutor in the room to answer questions. Only one respondent indicated that they had taken mathematics classes in another format. Table 27 provides specific details of the response to this question.

Table 27

Previous Instructional Formats for Intermediate Algebra Students

Instructional Format	Frequency	Percent
Traditional on-campus	80	70.8
Computer-based on-campus	17	15.0
Distance Education	2	1.8
Self Paced	12	10.6
Other	1	.9
Missing	1	.9
Total	113	100

Equality of Groups

Two multiple analysis of variance (MANOVA) analyses were conducted to separately examine the Elementary Algebra and Intermediate Algebra groups within each type of instructional method (traditional classroom, on-campus computer-based instruction and computer-based instruction at a distance.) The MANOVA analysis was conducted for final grade and final exam for each group (Elementary Algebra and Intermediate Algebra). An alpha level of .05 was used for all statistical tests.

Beginning Algebra

For the Beginning Algebra group, when the MANOVA was attempted there were 10 subjects in the Distance Education group, 28 subjects in the traditional instruction group, and 23 subjects in the CBI group who met the criteria of having both a final exam score and a final grade score. These cell sizes were proportional and representative of the sample, however they were unequal to each other. A MANOVA analysis was performed and unequal cell sizes can produce a sizable distortion in the Type I error rate in this type of analysis. A cautious examination was made of the descriptive statistics of the three groups that would make up this analysis using Table 6. For both the final grade and final exam, the standard deviation for the scores of the distance education group fell between the traditional group (which had the highest standard deviation) and the CBI group (which had the lowest standard deviation). Since the standard deviations for the scores of the distance group seemed to be representative of the population, and since distance education was a major component of the original research goals of this project, it was decided to include the distance education group in the MANOVA analysis.

Interpreting the multivariate composite variable created by combining final exam score and final grade score, the Wilks' Lambda statistic for the Beginning Algebra group showed that there was a statistical significance ($F = 7.374$, $p < .001$, eta squared=.206). This finding was interpreted as showing a difference on the mean vectors between the three groups (distance education, traditional and CBI), and therefore the groups were not equal in respect to their achievement.

The eta square is a measure of the effect size, which according to Hinckle, Wiersma and Jurs (1988) is the extent to which a phenomenon exists or in which groups differ in the sample on the dependent variables. Cohen's rules of thumb on effect size (Stevens, 1996), states that an effect size larger than .14 is interpreted to be large, however it is commonly held that one can not interpret the effect size without a meta-analysis of similar studies (Randall Schumacher, Personal Communication, September 14, 1999), which was not available for this study.

Since there was a statistical significance in the multivariate analysis, the next step was to look at the dependent variables (final grade and final exam score) and perform a univariate analysis to determine which was contributing most to the composite variate. In this analysis, final grade percentage was found to contribute most of the variation. Final exam did not contribute a significant amount of variation. See Table 28 for a detailed presentation of this data.

Table 28

Univariate Analysis of Dependent Variables for Beginning Algebra

Dependent Variable	Type II Sum of Squares	df	F	Significance
Final Exam	5556.959	2	.529	.592
Final Grade	2241.441	2	7.005	.002

Since there were three groups in the Beginning Algebra sample and there was a significant difference in the final grade, a Scheffé post-hoc analysis was conducted. This analysis showed a statistically significant difference (p=. 003) between the traditional and CBI groups. For Beginning Algebra students who met the criteria of taking the final examination, the CBI group received significantly higher final grades than the traditionally group with respective mean scores of 85.30 and 72.32 as shown in Table 6. There was no significant difference on final grade between the distance and CBI groups, or the traditional and distance groups. See Table 29 for a detailed illustration of the Scheffé analysis.

Table 29

Scheffé Post Hoc Analysis for Beginning Algebra Final Grade Percentage

Method (i)	Method (j)	Mean Difference (i-j)	Standard Error	Significance
Traditional	CBI	-12.98	3.56	.003
	Distance Ed	-2.18	4.66	.897
CBI	Traditional	12.98	3.56	.003
	Distance Ed	10.80	4.79	.087
Distance Ed	Traditional	2.18	4.66	.897
	CBI	-10.80	4.79	.087

Intermediate Algebra

For the Intermediate Algebra group, when the MANOVA was attempted there were only four people in the distance education group who met the criteria of having both a final exam score and a final grade score. There were 24 subjects in the traditional instruction group, 17 subjects in the CBI group and four subjects in the distance education group. When performing a MANOVA, cell sizes must be equal or proportional. It was determined that the distance education group size was not proportional to the sample. Therefore, the distance education group was not considered in the MANOVA analysis. Hence, a two-group MANOVA was performed.

Interpreting the multivariate Wilks' Lambda statistic for the composite variable created by combining the final exam score and the final grade score for the Intermediate Algebra group showed that there was a statistical significance ($F = 21.967$, $p < .001$, eta squared=.536). This finding was interpreted as showing a difference on the mean vectors between the two groups (traditional and CBI), and therefore the groups were not equal.

Since there was a statistical significance in the multivariate analysis, the next step was to look at the two dependent variables (final grade and final exam score) and perform a univariate analysis to determine which was contributing most to the composite variate. In this analysis, final exam percentage was found to contribute most of the variation. Final grade did not contribute a significant amount of variation. See Table 30 for a detailed presentation of this data.

Table 30

Univariate Analysis of Dependent Variables for Intermediate Algebra

Dependent Variable	Type II Sum of Squares	df	F	Significance
Final Exam	3031.36	1	7.735	.008
Final Grade	162.239	1	.959	.334

Differences in Attrition Between Instructional Formats

Next the differences in attrition rates for developmental mathematics classes taught in the traditional format, the on-campus computer-aided format and the computer-aided at a distance format were examined. Since the dependent variable of attrition was dichotomous, the chi square statistic was examined separately for the parallel sample groups (Beginning Algebra and Intermediate Algebra). Each test was conducted at the .05 alpha level.

Beginning Algebra

There were 135 subjects in the Beginning Algebra group. Of these, about one third dropped the course and two thirds persisted. In the traditional instruction group, about 15 percent of the subjects dropped the course, the CBI group, about 40 percent of the students dropped and in the distance education group 50 percent of the students dropped. Table 31 provides a detailed summary of the differences in attrition for the Beginning Algebra group.

A chi square analysis was carried out to determine if the attrition was equal in the three teaching methods (traditional, CBI and distance education). Since the calculated value of chi square was significant (χ^2 (2, $\underline{N}$ = 135) = 11.723, $\underline{p}$ = .003) it was concluded that the differences in attrition between the three methods were too great to be attributed to sampling fluctuation.

To determine which of the methods were major contributors to the statistically significant chi square value, standardized residuals were calculated (see Table 31 for results). According to Hinkle, Wiersma and Jurs (1988), "when a standardized residual for a category is greater than 2.00 (in absolute value), the researcher can conclude that it is a major contributor to the significant χ^2 value" (556). Since the standardized residuals for the traditionally taught group were greater than 2.00 in both the dropped and persisted categories, it can be concluded that there were fewer students dropping and more students persisting than expected in the traditionally taught group.

Table 31

Beginning Algebra Differences in Attrition and Standardized Residuals

Method		Dropped	Persisted	Total
Traditional	Frequency	7	40	47
	% within method	14.9	85.1	100
	Expected Frequency	15.67	31.33	47
	Standardized Residual	-2.19	7.54	
CBI	Frequency	26	38	64
	% within method	40.6	59.4	100
	Expected Frequency	21.33	42.67	64
	Standardized Residual	1.01	-0.74	
Distance Education	Frequency	12	12	24
	% within method	50.0	50.0	100
	Expected Frequency	8	16	24
	Standardized Residual	1.41	-1.00	
Total	Frequency	45	90	135
	% within method	33.3	66.7	100

Intermediate Algebra

There were 113 subjects in the Intermediate Algebra group. Of these, about 43% dropped the course and 57% persisted. In the traditional instruction group, about 37% of the subjects dropped, the CBI group, about 40.8% of the students dropped and in the distance education group 66.7% of the students dropped. Table 32 provides a detailed summary of the differences in attrition for the Intermediate Algebra group.

Table 32

Intermediate Algebra Differences in Attrition and Standardized Residuals

Method		Dropped	Persisted	Total
Traditional	Frequency	17	29	46
	% within method	37.0	63.0	100
	Expected Frequency	19.9	26.1	46
	Standardized Residual	-0.7	0.6	
CBI	Frequency	20	29	49
	% within method	40.8	59.2	100
	Expected Frequency	21.2	27.8	49
	Standardized Residual	-0.3	0.2	
Distance Education	Frequency	12	6	18
	% within method	66.7	33.3	100
	Expected Frequency	7.8	10.2	18
	Standardized Residual	1.5	-1.3	
Total	Frequency	49	64	113
	% within method	43.4	56.6	100

A chi square analysis was carried out to determine if the variables were independent of each other. Since the calculated value of chi square (χ^2 (2, N = 113) =

4.878, p=. 087) was not significant the differences in attrition for Intermediate Algebra between the three methods were attributed to sampling fluctuation.

Prediction of Final Grade, Final Exam Score and Attrition

Next, questions four (Can achievement as measured by final grade be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based in the classroom and computer-based at a distance instruction)?), five (Can achievement as measured by final exam score be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based in the classroom and computer-based at a distance instruction)?) and six (Can attrition be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based in the classroom and computer-based at a distance instruction)?) were analyzed through regression analysis. Regression models were used for each sample group (Beginning Algebra and Intermediate Algebra) to examine the effect of the independent variables (instructional method, locus of control, learning style and mathematics anxiety) on predicting the dependent variables (achievement as measured by final grade (on a scale of 0-100%), achievement as measured by final exam score and attrition within each instructional method (traditional classroom, on-campus computer-based and computer-based at a distance). Logistic regression was used to examine attrition across the three different methods of instruction and normal regression (using the default SPSS "Enter" method where all variables in a block are entered in a single step) was used to examine final exam and final course grade across the three different methods of instruction. Each test was conducted at the .05 alpha level.

For each sample group, the logistic regression analysis (with attrition as the criterion variable and total math anxiety, locus of control, learning type and method as independent variables) required recoding of nominal independent variables. Tables 33 and 34 show the dummy coding scheme as well as the variable names used in the equations for both the Beginning and Intermediate Algebra groups.

Table 33

Dummy Coding and Variable Names for Instructional Method

	CBI	Traditional	Distance
Dummy Code	0 1	0 1	0 0
Variable Name	D1	D2	

Table 34

Dummy Coding and Variable Names for Learning Type

	Quad 1	Quad 2	Quad 3	Quad 4	No Single Type
Dummy Code	1 0 0 0	0 1 0 0	0 0 1 0	0 0 0 1	0 0 0 0
Variable Name	DTYPE1	DTYPE2	DTYPE4	DTYPE5	

Beginning Algebra

In the regression analysis with final exam percentage as the criterion variable and total math anxiety, locus of control, learning type and method as independent variables R^2 was .036, $\underline{F}$ (4, 53) = .492, $\underline{p}$=.742. None of the independent variables contributed significantly to the model. Table 35 provides a summary of the results obtained in this analysis.

Table 35

Multiple Regression with Beginning Algebra Final Exam Percentage as the Criterion

Variable	B	SE B	β	t	p
Total Math Anxiety	.527	4.409	.016	.120	.905
Locus of Control	-.508	.910	-.076	-.558	.579
Learning Type	-.383	2.488	-.021	-.154	.878
Method	5.166	4.143	.169	1.247	.218

In the regression analysis with final grade percentage as the criterion variable and total math anxiety, locus of control, learning type and method as independent variables R^2 was .097, F (4, 82) = 2.199, p=.076. None of the independent variables contributed significantly to the model. Table 36 provides a summary of the results obtained in this analysis.

Table 36

Multiple Regression with Beginning Algebra Final Grade Percentage as the Criterion

Variable	B	SE B	β	t	p
Total Math Anxiety	-5.287	3.408	-.167	-1.551	.125
Locus of Control	-1.213	.767	-.168	-1.582	.117
Learning Type	-2.306	2.074	-.177	-1.112	.270
Method	3.170	3.862	.087	.821	.414

The logistic regression (using the dummy variables in Tables 33 and 34) with attrition as the criterion variable for Beginning Algebra yielded the following equation:

Logit (Attrition) = -.6419 + (1.8123 x D1) + (.4067 x D2) + (.5122 x DTYPE1)

+ (-.1051 x DTYPE2) + (.3209 x DTYPE3) + (.4481 x DTYPE4)

+ (.0192 x Locus of Control Value) + (.0992 x Math Anxiety Variable)

The equation was then analyzed using values of 10 and 11 for the locus of control variable (which represented internal and external locus of control as dictated by the locus of control instrument) and values of 1, 3 and 5 for the mathematics anxiety variable to represent low, moderate and high levels of anxiety. The probability of persistence was then calculated using the formula: Probability of persistence = [1 / (1 + exp (-logit))]. Tables 37 through 42 detail the logits and probability of attrition. It is interesting to note that in every case, the probability of attrition is less in the traditional group.

The test statistics were then examined for each of the coefficient values and it was found that only the traditional method was significant (Wald = 8.955, $\underline{df} = 1$, $\underline{p} = .0027$) with an effect size estimated by the Cox and Snell R^2 at .108 and by the Nagelkerke R^2 as .150. This conclusion was supported when examining the matrix model variance versus the model variance. The -2 log likelihood for the matrix variance was 171.86, while -2 log likelihood for the model with all the test variables included was 156.39. When the equation included only the traditional method and the constant the -2 log likelihood was 159.91. This can be interpreted as meaning that the model that best predicts attrition includes only the factor of whether or not the student is enrolled in a traditionally taught class. Learning style, mathematics anxiety and locus of control do not help to explain attrition in Beginning Algebra.

Table 37

Probability of Attrition in Beginning Algebra for Internal Locus of Control, Low Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	1.9738	0.12
CBI	Quadrant One	0.5682	0.36
Distance	Quadrant One	0.1615	0.46
Traditional	Quadrant Two	1.3565	0.20
CBI	Quadrant Two	-0.0491	0.51
Distance	Quadrant Two	-0.4558	0.61
Traditional	Quadrant Three	1.7825	0.14
CBI	Quadrant Three	0.3769	0.41
Distance	Quadrant Three	-0.0298	0.51
Traditional	Quadrant Four	1.9097	0.13
CBI	Quadrant Four	0.5041	0.38
Distance	Quadrant Four	0.0974	0.48
Traditional	No Single Type	1.4616	0.19
CBI	No Single Type	0.056	0.49
Distance	No Single Type	-0.3507	0.59

Table 38

Probability of Attrition in Beginning Algebra for External Locus of Control, Low Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	1.993	0.12
CBI	Quadrant One	0.5874	0.36
Distance	Quadrant One	0.1807	0.45
Traditional	Quadrant Two	1.3757	0.20
CBI	Quadrant Two	-0.0299	0.51
Distance	Quadrant Two	-0.4366	0.61
Traditional	Quadrant Three	1.8017	0.14
CBI	Quadrant Three	0.3961	0.40
Distance	Quadrant Three	-0.0106	0.50
Traditional	Quadrant Four	1.9289	0.13
CBI	Quadrant Four	0.5233	0.37
Distance	Quadrant Four	0.1166	0.47
Traditional	No Single Type	1.4808	0.19
CBI	No Single Type	0.0752	0.48
Distance	No Single Type	-0.3315	0.58

Table 39

Probability of Attrition in Beginning Algebra for Internal Locus of Control, Moderate Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	2.1722	0.10
CBI	Quadrant One	0.7666	0.32
Distance	Quadrant One	0.3599	0.41
Traditional	Quadrant Two	1.5549	0.17
CBI	Quadrant Two	0.1493	0.46
Distance	Quadrant Two	-0.2574	0.56
Traditional	Quadrant Three	1.9809	0.12
CBI	Quadrant Three	0.5753	0.36
Distance	Quadrant Three	0.1686	0.46
Traditional	Quadrant Four	2.1081	0.11
CBI	Quadrant Four	0.7025	0.33
Distance	Quadrant Four	0.2958	0.43
Traditional	No Single Type	1.66	0.16
CBI	No Single Type	0.2544	0.44
Distance	No Single Type	-0.1523	0.54

Table 40

Probability of Attrition in Beginning Algebra for External Locus of Control, Moderate Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	2.1914	0.10
CBI	Quadrant One	0.7858	0.31
Distance	Quadrant One	0.3791	0.41
Traditional	Quadrant Two	1.5741	0.17
CBI	Quadrant Two	0.1685	0.46
Distance	Quadrant Two	-0.2382	0.56
Traditional	Quadrant Three	2.0001	0.12
CBI	Quadrant Three	0.5945	0.36
Distance	Quadrant Three	0.1878	0.45
Traditional	Quadrant Four	2.1273	0.11
CBI	Quadrant Four	0.7217	0.33
Distance	Quadrant Four	0.315	0.42
Traditional	No Single Type	1.6792	0.16
CBI	No Single Type	0.2736	0.43
Distance	No Single Type	-0.1331	0.53

Table 41

Probability of Attrition in Beginning Algebra for Internal Locus of Control, High Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	2.3706	0.09
CBI	Quadrant One	0.965	0.28
Distance	Quadrant One	0.5583	0.36
Traditional	Quadrant Two	1.7533	0.15
CBI	Quadrant Two	0.3477	0.41
Distance	Quadrant Two	-0.059	0.51
Traditional	Quadrant Three	2.1793	0.10
CBI	Quadrant Three	0.7737	0.32
Distance	Quadrant Three	0.367	0.41
Traditional	Quadrant Four	2.3065	0.09
CBI	Quadrant Four	0.9009	0.29
Distance	Quadrant Four	0.4942	0.38
Traditional	No Single Type	1.8584	0.13
CBI	No Single Type	0.4528	0.39
Distance	No Single Type	0.0461	0.49

Table 42

Probability of Attrition in Beginning Algebra for External Locus of Control, High Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	2.3898	0.08
CBI	Quadrant One	0.9842	0.27
Distance	Quadrant One	0.5775	0.36
Traditional	Quadrant Two	1.7725	0.15
CBI	Quadrant Two	0.3669	0.41
Distance	Quadrant Two	-0.0398	0.51
Traditional	Quadrant Three	2.1985	0.10
CBI	Quadrant Three	0.7929	0.31
Distance	Quadrant Three	0.3862	0.40
Traditional	Quadrant Four	2.3257	0.09
CBI	Quadrant Four	0.9201	0.28
Distance	Quadrant Four	0.5134	0.37
Traditional	No Single Type	1.8776	0.13
CBI	No Single Type	0.472	0.38
Distance	No Single Type	0.0653	0.48

When the classification table for attrition in Beginning Algebra is examined (Table 43) it can be seen that the logistic regression model correctly classifies about 73%

of the group. This suggests that the model predicts attrition more accurately than chance, which would correctly classify 50% of the group members.

Table 43

Classification Table for Attrition in Beginning Algebra

	Predicted		
Observed	Drop	Otherwise	Percent Correct
Drop	12	33	26.7%
Otherwise	4	86	95.56%
		Overall	72.59%

Intermediate Algebra

In the regression analysis with final exam percentage as the criterion variable and total math anxiety, locus of control, learning type and method as independent variables, R^2 was .285, $\underline{F}$ (4, 39) = 3.887, $\underline{p}$=.009. Total math anxiety contributed significantly to the model. If locus of control, learning type and method were omitted, no statistical significance would be lost. Table 44 provides a summary of the results obtained in this analysis.

In the regression analysis with final grade percentage as the criterion variable and total math anxiety, locus of control, learning type and method as independent variables R^2 was .173, $\underline{F}$ (4, 53) = 2.773, $\underline{p}$=.036. Locus of control contributed significantly to the model. Total math anxiety, learning type and method could be eliminated from the model without losing any statistical significance. Table 45 provides a summary of the results obtained in this analysis.

Table 44

Intermediate Algebra Multiple Regression with Final Exam Percentage as the Criterion

Variable	B	SE B	β	t	p
Total Math Anxiety	-12.834	4.042	-.431	-3.175	.003
Locus of Control	-1.257	.887	-.193	-1.417	.165
Learning Type	1.174	2.540	.063	.462	.647
Method	-7.946	4.150	-.260	-1.915	.063

Table 45

Intermediate Algebra Multiple Regression with Final Grade Percentage as the Criterion

Variable	B	SE B	β	t	p
Total Math Anxiety	-1.788	4.172	-0.54	-.429	.670
Locus of Control	-2.855	.916	-.392	-3.118	.003
Learning Type	2.522	2.621	.121	.962	.340
Method	-2.957	4.283	-.087	-.691	.493

The logistic regression (using the dummy variables and variable names as noted in Tables 33 and 34) with attrition as the criterion variable for Intermediate Algebra yielded the following equation:

Logit (Attrition) = -.5180 + (1.3596 x D1) + (1.2341 x D2) + (.5346 x DTYPE1)

+ (.6484 x DTYPE2) + (.9534 x DTYPE3) + (.1559 x DTYPE4)

+ (.0153 x Locus of Control Variable) + (-.4926 x Math Anxiety Variable)

The equation was then analyzed using values of 10 and 11 for the locus of control variable (which represented internal and external locus of control as dictated by the locus of control instrument) and values of 1, 3 and 5 for the mathematics anxiety variable to represent low, moderate and high levels of anxiety respectively. The probability of attrition was then calculated using the formula: Probability of persistence = [1 / (1 + exp (-logit))]. Tables 46 through 51 detail the logits and probability of attrition. It is interesting to note that in each case, the probability of attrition is greater in the in the distance education group than in the traditional or CBI groups.

The test statistics were then examined for each of the coefficient values and it was found that only the traditional (Wald = 4.8263, df = 1, p = .0280) and CBI (Wald = 4.1223, df = 1, p = .0423) methodologies were significant. Effect size for each of these is estimated by the Cox and Snell R^2 at .086 and by the Nagelkerke R^2 as .115. This conclusion was supported when examining the matrix model variance versus the model variance. The -2 log likelihood for the matrix variance was 154.65, while -2 log likelihood for the model with all the test variables included was 144.49. When the equation included only the traditional methods and the constant, the -2 log likelihood was 153.35. When the equation included only the CBI method and the constant, the -2 log likelihood was 154.43. This can be interpreted as meaning that the model that best predicts attrition includes only the factor of whether or not the student is enrolled in a traditionally or CBI methodology of instruction. Learning style, mathematics anxiety and locus of control do not help to explain attrition in Intermediate Algebra.

Table 46

Probability of Attrition in Intermediate Algebra for Internal Locus of Control, Low Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	1.0366	0.26
CBI	Quadrant One	0.9111	0.29
Distance	Quadrant One	-0.3230	0.58
Traditional	Quadrant Two	1.1504	0.24
CBI	Quadrant Two	1.0249	0.26
Distance	Quadrant Two	-0.2092	0.55
Traditional	Quadrant Three	1.4554	0.19
CBI	Quadrant Three	1.3299	0.21
Distance	Quadrant Three	0.0958	0.48
Traditional	Quadrant Four	0.6579	0.34
CBI	Quadrant Four	0.5324	0.37
Distance	Quadrant Four	-0.7017	0.67
Traditional	No Single Type	0.5020	0.38
CBI	No Single Type	0.3765	0.41
Distance	No Single Type	-0.8576	0.70

Table 47

Probability of Attrition in Intermediate Algebra for External Locus of Control, Low Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	1.0519	0.26
CBI	Quadrant One	0.9264	0.28
Distance	Quadrant One	-0.3077	0.58
Traditional	Quadrant Two	1.1657	0.24
CBI	Quadrant Two	1.0402	0.26
Distance	Quadrant Two	-0.1939	0.55
Traditional	Quadrant Three	1.4707	0.19
CBI	Quadrant Three	1.3452	0.21
Distance	Quadrant Three	0.1111	0.47
Traditional	Quadrant Four	0.6732	0.34
CBI	Quadrant Four	0.5477	0.37
Distance	Quadrant Four	-0.6864	0.67
Traditional	No Single Type	0.5173	0.37
CBI	No Single Type	0.3918	0.40
Distance	No Single Type	-0.8423	0.70

Table 48

Probability of Attrition in Intermediate Algebra for Internal Locus of Control, Moderate Math Anxiety Subjects

Method	Learning Type	Logodds	Probability of Attrition
Traditional	Quadrant One	0.0514	0.49
CBI	Quadrant One	-0.0741	0.52
Distance	Quadrant One	-1.3082	0.79
Traditional	Quadrant Two	0.1652	0.46
CBI	Quadrant Two	0.0397	0.49
Distance	Quadrant Two	-1.1944	0.77
Traditional	Quadrant Three	0.4702	0.38
CBI	Quadrant Three	0.3447	0.41
Distance	Quadrant Three	-0.8894	0.71
Traditional	Quadrant Four	-0.3273	0.58
CBI	Quadrant Four	-0.4528	0.61
Distance	Quadrant Four	-1.6869	0.84
Traditional	No Single Type	-0.4832	0.62
CBI	No Single Type	-0.6087	0.65
Distance	No Single Type	-1.8428	0.86

Table 49

Probability of Attrition in Intermediate Algebra for External Locus of Control, Moderate Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	0.0667	0.48
CBI	Quadrant One	-0.0588	0.51
Distance	Quadrant One	-1.2929	0.78
Traditional	Quadrant Two	0.1805	0.45
CBI	Quadrant Two	0.0550	0.49
Distance	Quadrant Two	-1.1791	0.76
Traditional	Quadrant Three	0.4855	0.38
CBI	Quadrant Three	0.3600	0.41
Distance	Quadrant Three	-0.8741	0.71
Traditional	Quadrant Four	-0.3120	0.58
CBI	Quadrant Four	-0.4375	0.61
Distance	Quadrant Four	-1.6716	0.84
Traditional	No Single Type	-0.4679	0.61
CBI	No Single Type	-0.5934	0.64
Distance	No Single Type	-1.8275	0.86

Table 50

Probability of Attrition in Intermediate Algebra for Internal Locus of Control, High Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	-0.9338	0.72
CBI	Quadrant One	-1.0593	0.74
Distance	Quadrant One	-2.2934	0.91
Traditional	Quadrant Two	-0.82	0.69
CBI	Quadrant Two	-0.9455	0.72
Distance	Quadrant Two	-2.1796	0.90
Traditional	Quadrant Three	-0.515	0.63
CBI	Quadrant Three	-0.6405	0.65
Distance	Quadrant Three	-1.8746	0.87
Traditional	Quadrant Four	-1.3125	0.79
CBI	Quadrant Four	-1.438	0.81
Distance	Quadrant Four	-2.6721	0.94
Traditional	No Single Type	-1.4684	0.81
CBI	No Single Type	-1.5939	0.83
Distance	No Single Type	-2.828	0.94

Table 51

Probability of Attrition in Intermediate Algebra for External Locus of Control, High Math Anxiety Subjects

Method	Learning Type	Logit	Probability of Attrition
Traditional	Quadrant One	-0.9185	0.71
CBI	Quadrant One	-1.0440	0.74
Distance	Quadrant One	-2.2781	0.91
Traditional	Quadrant Two	-0.8047	0.69
CBI	Quadrant Two	-0.9302	0.72
Distance	Quadrant Two	-2.1643	0.90
Traditional	Quadrant Three	-0.4997	0.62
CBI	Quadrant Three	-0.6252	0.65
Distance	Quadrant Three	-1.8593	0.87
Traditional	Quadrant Four	-1.2972	0.79
CBI	Quadrant Four	-1.4227	0.81
Distance	Quadrant Four	-2.6568	0.93
Traditional	No Single Type	-1.4531	0.81
CBI	No Single Type	-1.5786	0.83
Distance	No Single Type	-2.8127	0.94

When the classification table for attrition in Intermediate Algebra is examined (Table 52) it can be seen that the logistic regression model correctly classifies about 65% of the group. This suggests that the model predicts attrition somewhat more accurately than chance, which would correctly classify 50% of the group members.

Table 52

Classification Table for Attrition in Intermediate Algebra

	Predicted		
Observed	Drop	Otherwise	Percent Correct
Drop	20	29	40.82%
Otherwise	11	53	82.81%
		Overall	64.60%

Demographic Relationships

The relationship of age, ethnicity, gender, previous mathematics courses, previous attempts and employment status to final exam grade and final grade was examined in an exploratory manner with correlational statistics. Pearson correlations were used for all correlation combinations involving final exam and final grade. Although a point-biserial correlation would have been a more appropriate methodology for correlations with combinations of nominal data and final exam/final exam (which was interval/ratio data), it was not available in the SPSS statistical package that was used for data analysis in this study. The Kendall's tau coefficient was used for correlation combinations that involved only non-parametric, nominal data. Separate analyses were conducted for the Beginning

Algebra and the Intermediate Algebra groups. The .05 alpha level was used as an indicator of significant correlation.

Beginning Algebra

For the Beginning Algebra group, 61 students received a final exam percentage, and 90 students received a final grade percentage. Only gender was significantly correlated to final exam percentage (r = .429, p = .001) and final grade percentage (r = .211, p = .046). Thus, for this Beginning Algebra, females tended to have higher math grades than males. These findings agree with Branum's (1990) research in that gender was a significant predictor of mathematics achievement. A complete illustration of the correlations for Beginning Algebra is given in Table 53.

All 135 Beginning Algebra students in the research sample were considered in the correlations involving attrition. No significant correlational relationships with attrition were found. Table 53 illustrates the results in detail.

Table 53

Demographic Correlations with Final Exam, Final Grade and Attrition for Beginning Algebra

		Final Exam Percentage	Final Grade Percentage	Attrition
Age	Correlation	.247	.132	-.012
	Significance (2-tailed)	.055	.214	.890
	Coefficient	Pearson	Pearson	Pearson
Ethnicity	Correlation	-.059	.099	-.087
	Significance (2-tailed)	.553	.230	.281
	Coefficient	Pearson	Pearson	Kendall's tau
Gender	Correlation	.429	.211	.000
	Significance (2-tailed)	.001	.046	1.00
	Coefficient	Pearson	Pearson	Kendall's tau
Previous instructional format	Correlation	.073	-.035	-.056
	Significance (2-tailed)	.577	.741	.500
	Coefficient	Pearson	Pearson	Kendall's tau
Previous attempts	Correlation	-1.09	.050	-.099
	Significance (2-tailed)	.403	.641	.255
	Coefficient	Pearson	Pearson	Kendall's tau
Employment Status	Correlation	.134	.124	-.111
	Significance (2-tailed)	.302	.243	.202
	Coefficient	Pearson	Pearson	Kendall's tau
Method of Funding	Correlation	.050	.011	-.056
	Significance (2-tailed)	.700	.921	.491
	Coefficient	Pearson	Pearson	Kendall's tau

Intermediate Algebra

For the Intermediate Algebra group, 58 students received a final exam percentage, and 44 students received a final grade percentage. Age (r = .323, p = .013) was significantly correlated to final exam percentage. Thus, for the Intermediate Algebra group, as the students got older they were more likely to have received a higher final exam percentage. A complete illustration of the correlations for Intermediate Algebra is given in Table 54.

All 113 Intermediate Algebra students in the research sample were considered in the correlations involving attrition. The number of previous attempts (r = -.260, p = .005) was significantly correlated to attrition. Thus, for the Intermediate Algebra group, as the previous number of attempts at the class rose, the students were more likely to drop the course. Table 54 illustrates the results in detail.

Table 54

Demographic Correlation for Final Exam, Final Grade and Attrition for Beginning Algebra

		Final Exam Percentage	Final Grade Percentage	Attrition
Age	Correlation	.323	-.148	.115
	Significance (2-tailed)	.013	.338	.228
	Coefficient	Pearson	Pearson	Pearson
Ethnicity	Correlation	-.106	.061	-.064
	Significance (2-tailed)	.424	.692	.464
	Coefficient	Pearson	Pearson	Kendall's tau
Gender	Correlation	-.146	-.196	.017
	Significance (2-tailed)	.271	.198	.854
	Coefficient	Pearson	Pearson	Kendall's tau
Previous instructional format	Correlation	.061	.218	-.008
	Significance (2-tailed)	.650	.154	.926
	Coefficient	Pearson	Pearson	Kendall's tau
Previous attempts	Correlation	-.208	-.221	-.260
	Significance (2-tailed)	.117	.150	.005
	Coefficient	Pearson	Pearson	Kendall's tau
Employment Status	Correlation	-.201	.031	.083
	Significance (2-tailed)	.130	.841	.384
	Coefficient	Pearson	Pearson	Kendall's tau
Method of Funding	Correlation	.086	-.017	-.019
	Significance (2-tailed)	.576	.899	.841
	Coefficient	Pearson	Pearson	Kendall's tau

Summary

The data analysis presented in this chapter provided a basis for developing the conclusions and recommendations that follow in the next chapter. The 135 usable surveys in the Beginning Algebra group and the 113 usable surveys in the Intermediate Algebra group were analyzed and discussed in narrative form and presented in Tables when appropriate. The six sections of this chapter provided an in-depth look at the response rates, the characteristics of the population and the specific findings for the study's seven research questions including an exploratory examination of the demographic characteristics and correlations of the sample groups.

CHAPTER 5

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Introduction

The purpose of this chapter is to summarize the purpose, literature, methodology, procedures and results of this study. The purpose of this study was to investigate the relationship between individual student differences and academic success (as measured by final exam score and final class grade) in three pedagogical methods (traditional classroom, computer-aided in an on-campus setting, and computer-aided in a distance education setting) for developmental mathematics classes at the community college level. Locus of control, math anxiety and learning style were the specific individual differences that were examined in this study.

A secondary purpose was exploratory and examined whether other student characteristics (such as age, ethnicity, gender, previous mathematics courses, previous attempts, and employment status) predicted the academic success of individual students in the three different instructional methods (traditional, computer-based on campus and computer-based at a distance) of developmental mathematics.

Two parallel sample groups were used (Beginning and Intermediate Algebra) to examine the specific research questions addressed by this study, which were:

1. Are there differences in achievement as measured by final grade (on a scale from 0 - 100%) between developmental mathematics classes taught in the traditional

format, the computer-aided in the classroom format, and the computer-aided at a distance format?

2. Are there differences in achievement as measured by final exam score between developmental mathematics classes taught in the traditional format, the computer-based in the classroom format, and the computer-based at a distance format?

3. Are there differences in attrition (persisted vs. dropped out) between developmental mathematics classes taught in the traditional format, the computer-based in the classroom format, and the computer-aided at a distance format?

4. Can achievement, as measured by final grade (on a scale from 0 - 100%) be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

5. Can achievement, as measured by final exam score be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

6. Can attrition (persisted vs. dropped out) be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based instruction in the classroom and computer-based instruction at a distance)?

7. Are age, ethnicity, gender, previous mathematics courses, previous attempts and employment status related to final exam grade, final grade (on a scale from 0 - 100%) and attrition?

Summary of Procedures

This study was necessary to synthesize past literature on factors predicting student success and to apply it in the identification of student characteristics that could help predict success in different modalities of developmental mathematics classes at the community college level. The review of literature outlined previous and related findings.

The method used to gather information was a survey. In addition, final grade percentage, final exam percentage and attrition information was collected at the end of the semester. Surveys were distributed to Beginning and Intermediate Algebra students. The on-campus students received their surveys during class and returned them on a subsequent class meeting. Surveys were mailed directly to distance education students.

The survey was made up of four instruments: The Rotter Internal-External (I-E) Scale, the Abbreviated Mathematics Anxiety Rathing Scale (AMARS) by Alexander and Martray (1989), the Learning Type Measure (LTM) (McCarthy & St. Germain, 1998a), and a supplemental questionnaire which gathered demographic information.

To determine if there were significant differences in achievement (as measured by final exam percentage and final grade percentage) between the three formats of instruction (traditional, computer-based in a classroom setting and computer-based at a distance) a MANOVA analysis was calculated. If the Wilks' Lambda statistic was significant at the .05 alpha level, it was interpreted as showing a difference on the mean vectors between the three groups, and therefore the groups were not equal. If significance was shown in the multivariate analysis a univariate analysis was conducted to determine which of the independent variables were contributing to the composite variable.

To determine if there were significant differences in attrition among the three instructional methods (traditional, computer-based in a classroom setting and computer-based at a distance), a Chi Square value was calculated. If the Chi Square value exceeded the critical value, a statistically significant difference was considered to be present. When a significant difference was present, the residuals were calculated to determine which groups had the greatest difference.

To determine if achievement (as measured by final exam percentage and final grade percentage) could be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based in a classroom setting and computer-based at a distance) regression analysis was utilized. If the R^2 value was significant at the .05 alpha level, the probability values were examined to determine which of the independent variables contributed significantly to the model.

To determine if attrition could be predicted by math anxiety, locus of control or learning style within each instructional method (traditional, computer-based in a classroom setting and computer-based at a distance) logistic regression analysis was utilized. The probability of attrition was examined in conjunction with the Wald statistic for each coefficient in the logistic regression equation. If the Wald statistic was significant at the .05 alpha level, the independent variable associated with that coefficient was seen as significantly contributing to the prediction of attrition.

To determine if there were significant relationships between the demographic characteristics of age, ethnicity, gender, previous mathematics courses, previous attempts or employment status and final exam grade, final grade percentage and attrition, correlations were calculated. Correlations were considered significant at the .05 alpha level.

This study involved the use of two parallel sample groups, which were the Beginning Algebra group and the Intermediate Algebra group. Both groups were comprised of developmental mathematics students enrolled in classes during the Spring 1999 semester at North Lake Community College in Irving, Texas. The following sections of this chapter include the conclusions and subsequent recommendations drawn from the findings.

Conclusions

Surveys were distributed to 247 Beginning Algebra students and 173 Intermediate Algebra students. Valid responses were received from 135 Beginning Algebra students and 113 Intermediate Algebra students with return rates of 55% and 65% respectively. Specific conclusions for each of the research questions are reported in the following sections of this chapter: (a) differences in final grade and final exam scores between instructional formats, (b) differences in attrition between instructional formats, (c) prediction of final grade, final exam score and attrition, and (d) demographic relationships.

Differences in Final Grade and Final Exam Scores Between Instructional Formals

With regard to research questions one and two, it is the conclusion of this study that for the Beginning Algebra group, the instructional methods (traditional, CBI and distance education) were not equal with respect to final grade. CBI students received significantly higher final grades (with mean scores of 85%) than did the traditionally taught students (with mean scores of 72%). There was no significant difference on final grade between the distance education and CBI students or the traditional and distance education students. Final exam percentage did not significantly differ between the three instructional methods (see Chapter 4, Table 6).

The analysis of research questions one and two for the Intermediate Algebra group did not include the distance education students since there were only four subjects who met the criteria of having both a final exam score and a final grade score. It is the conclusion of this study that, for the Intermediate Algebra group, the instructional methods (traditional, CBI and distance education) were not equal with respect to final exam score. The traditional students (with mean scores of 60%) scored significantly higher than the CBI students (with mean scores of 42%) on the final exam. Final grade, however, did not significantly differ between the instructional methods (see Chapter 4, Table 14).

It is interesting to note that the results were different for the two groups (Beginning and Intermediate Algebra). In the Beginning Algebra group CBI students received significantly higher final grades than did the traditionally taught students while in the Intermediate Algebra group there was no significant difference between the instructional methods. With respect to final exam score, in the Beginning Algebra group the instructional methods were equal, while in the Intermediate Algebra group the traditional students scored significantly higher than the CBI students. There does not seem to be the clear-cut overall advantage for computer-mediated learning methodology in developmental mathematics as proposed by Academic Systems, Inc. (1996b, 1996c).

Differences In Attrition Between Instructional Formats

With regard to research question three, for the Beginning Algebra group it is the conclusion of this study that there were fewer students dropping and more students persisting than expected in the traditionally taught group. There was no significant difference in attrition between the three instructional methods for the Intermediate Algebra group. These results do not support previous research at Oklahoma State University where there was an eleven percent increase in persistence in developmental mathematics classes with the use of computer-mediated instruction (Academic Systems, Inc. 1996c). It may be that traditional instruction in developmental mathematics at North Lake College is a higher quality than that at Oklahoma State, or it may be that the differing results were due to random fluctuation. Further research is needed to fully understand these results.

Prediction Of Final Grade, Final Exam Score And Attrition

With regard to research questions four and five, it is the conclusion of this study that for the Beginning Algebra group that neither final exam achievement or final grade can be predicted using math anxiety, locus of control or learning type. For the Intermediate Algebra group, math anxiety was a significant predictor variable for final exam percentage and locus of control was a significant predictor variable for final grade percentage.

The results for the Intermediate Algebra relating math anxiety to final exam agree with findings by Head and Lindsey (cited in Risko, Fairbanks and Alvarez, 1991), that a high anxiety level impedes performance, at least for poor and average students. Green (1990) also contended that mathematics anxiety is often related to poor mathematics performance. Logically it makes sense that anxiety level would be a significant predictor of final exam score since exams are times when physical manifestations of mathematics anxiety, such as headaches, nausea, heart palpitations and dizziness (Zaslavsky, 1996) can negatively affect performance. The lack of significance in the Beginning Algebra group may be due to sampling fluctuation or to different student characteristics between the Beginning and Intermediate Algebra groups.

The lack of significant relationship between learning style, as measured by the 4MAT learning style inventory, and academic achievement extended Cordell's (1991) findings of a lack of significance between learning style and learning outcome to include an examination of traditional, distance and CBI developmental mathematics classes. Cordell's findings and the findings of this study suggest that further research concerning relationships between the 4MAT learning style inventory and academic achievement is not indicated. There appears to be no significant relationship.

This study did find a relationship between locus of control and final grade. The literature has shown mixed results with respect to the relationship of locus of and achievement. Dille and Mezack (1994) found that students with a more internal locus of control were more likely to be successful and earn a higher grade. Wills (1996) found that locus of control did not seem to have discriminating properties for developmental mathematics and English achievement, but suggested small sample size as the factor limiting the variability in the study. The results of this study give further evidence to the tenet that locus of control is indeed related to academic success, although apparently not for all developmental mathematics students.

With regard to research question six, Beginning Algebra students enrolled in traditionally taught classes persisted more often than those who were enrolled in the CBI or distance education methodologies. It is the conclusion of this study that, for the Beginning Algebra group, the model that best predicts attrition includes only the factor of instructional method, with students persisting more frequently if they were enrolled in a traditionally taught class. Learning style, mathematics anxiety and locus of control do not help to predict attrition. For the Intermediate Algebra group results were similar. Learning style, mathematics anxiety and locus of control did not help to predict attrition. Only instructional method significantly contributed to the model for predicting attrition, with traditional and CBI students persisting more frequently than distance education students.

The lack of relationship in this study between locus of control and attrition does not agree with previous research. Parker (1994) and Alman and Arambasich (1982) found that students with an internal locus of control showed a greater degree of persistence. Parker (1994) also found that locus of control was predictive of dropout. The characteristics of the developmental mathematics students in this study may have mediated the relationship of locus of control and attrition, as Lefcourt (1982) was noted to have suggested in Wilhite (1990) when discussing locus of control and achievement.

The relationship between learning style, as measured by the 4MAT learning style inventory, and attrition has not been well researched. The findings of this study suggest that, as with academic achievement, the 4MAT learning style instrument is not predictive of attrition. However, further research might be warranted examining this relationship with average college students rather than with developmental mathematics students.

Demographic Relationships

With regard to research question seven, few demographic characteristics were related to final exam grade and final course grade. For the Beginning Algebra group, it is the conclusion of this study that gender was significantly correlated to both final exam percentage and final grade percentage, with females more likely to receive a higher grade than males. For the Intermediate Algebra group, it is the conclusion of this study that age was significantly correlated to final exam percentage with older students more likely to receive a higher final exam percentage.

In regards to attrition, for the Beginning Algebra group it is the conclusion of this study that there were no significant correlations to age, ethnicity, gender, previous instructional format, previous attempts, employment status or method of funding. For the Intermediate Algebra group, it is the conclusion of this study that only the number previous attempts at the class was significantly correlated to attrition with .attrition rising as the number of previous attempts rose.

Recommendations

The conclusions of this study were based on the data collected from surveys distributed during the Spring 1999 semester as well as on achievement and attrition data provided by North Lake College faculty members, and are assumed to be characteristic of the developmental mathematics students at North Lake Community College. The results of this study have determined that, although outcomes are mixed, there are significant differences in the methods of instruction for developmental mathematics and there does appear to be some predictive power in locus of control and mathematics anxiety for academic success in developmental mathematics. Following are the recommendations for developmental mathematics at the community college level that have been made as a result of this study.

Developmental mathematics students should be tested for mathematics anxiety, and those who have high levels of mathematics anxiety should, at the least, be provided with materials on how to overcome their anxiety. This recommendation is particularly true for developmental mathematics at North Lake College where success on the final exam is used to determine whether a student may progress into higher-level math courses.

Developmental mathematics students should also be tested for locus of control. Although only the Intermediate Algebra group showed a significant relationship between locus of control and final grade, education on the concept of locus of control and how to change in a positive and more internal direction could only be of benefit to academically disadvantaged students.

Distance education developmental mathematics students have a very high attrition rate. This fact added to limited enrollment makes including their results in a comparative study very difficult. Future research should include more than one semester of results when enrollments are limited to ensure usable results.

There is a need to conduct further research into the efficacy of traditional, CBI and distance education methods of instruction for developmental mathematics. The findings of this study were somewhat mixed in this regard. In Beginning Algebra, students enrolled in CBI classes received higher final grades than did the traditionally taught students, but final exam percentage (which is the criterion used by North Lake College for advancement into higher level mathematics courses) did not differ significantly between the three methods. In Intermediate Algebra, traditional students scored higher than the CBI students on the final exam. However, final grade did not differ significantly between methods. CBI, which requires a significant investment in equipment and licensing fees for North Lake College, did not improve the students' achievement for final exam scores in the Beginning or Intermediate Algebra group. If North Lake College determines that the final exam is indeed the best indicator of learning for developmental mathematics students, it is doubtful whether the expense involved in the CBI instructional methodology is prudent. In addition, the CBI students did not persist at a greater rate than students enrolled in other methods of instruction. In fact, for the Beginning Algebra students, traditionally taught students persisted more often than CBI or distance education students. This may indicate that developmental students need more personal contact with an instructor in order to persist than is provided by CBI or distance education methodology, and again is an indication that the costs involved in the CBI instructional methodology may not be a good investment for developmental mathematics students.

Future researchers should consider removing the variation between instructors. This research did not focus on instructor differences, rather it considered all traditional instruction to be equal since the goal was to compare instructional methods and their respective predictors of success. However, the most predictive element for success in this study was instructional method. Since attrition was higher in some traditional classes than others, and since some classes achieved higher scores than others, an interesting study would be to attempt to quantify and remove instructor differences in the analysis phase, or to use those differences in the prediction of student success. There appears to be no magic technological solution to the quandary of low success rates among developmental mathematics students. Instructor/student personal contact may play a large role in student success in developmental mathematics.

Future research with the 4MAT Learning Style Instrument should also be conducted, but in a different way. An interesting and useful study would be one where an experimental group of developmental mathematics instructors are trained in the 4MAT method to identify and teach to different learning types. If the 4MAT-trained instructors experienced an increase in student retention and success the results would be a useful and practical addition to the field of developmental mathematics.

Further research is needed to replicate the findings relating mathematics anxiety and locus of control to academic success for developmental mathematics students. Although the findings of this study seem to support recommendations three and four, further research is needed to determine whether they will make a significant contribution to student success for academically disadvantaged students.

Finally, further research should focus on what happens to the students who drop out of developmental mathematics classes. Do they typically pass the class on the second or third try? How many times are these students motivated to come back and try again, and what types of factors keep them motivated? Included in a study of this sort should be an institutional level analysis of how funding to the college, which is based on program completion, is affected by attrition rates in developmental mathematics. It is possible that failure and attrition in developmental mathematics has a significant influence on the overall dropout rate of the entire college, and as such deserves a very high level of attention.

APPENDIX A

INFORMED CONSENT FORM

INFORMED CONSENT FORM

Title of investigation: Prediction of Community College Students' Success in Developmental Math with Traditional Classroom, Computer-Based On-Campus and Computer-Based at a Distance Instruction using Locus of Control, Math Anxiety and Learning Style

The purpose of this study is to investigate the possibility of predicting student success in different delivery modes of developmental mathematics. My participation will involve one block of time. I agree to complete four short forms:

1. The Rotter Internal-External Locus of Control
2. The Brief Mathematics Anxiety Rating Scale
3. The Learning Type Measure (LTM)
4. A Demographic Information Form

In order to use these factors to predict success, my results on the above measures will be used in conjunction with my final grade and final exam score. If I drop the class, my data will be used to attempt to predict and understand attrition. I understand that my participation is voluntary. I have been informed that all information gathered in this research study will be identified with the last five digits of my social security number. All information collected will be confidential, and neither my name nor the last five digits of my social security number will be used in the write-up at any time. The data will be aggregated for statistical purposes and all individual student information will be destroyed at the end of the research project.

I understand that there is no serious risk or discomfort to any participant. I am free to withdraw my consent and discontinue participation in this study at any time. My participation or lack of participation will not effect my grade. At the end of the semester, I have the option of obtaining my results from the four instruments listed above along with an explanation of how they may effect my learning. The possible benefit of my participation to others is the reduction of dropout and the increase in student success in developmental mathematics classes in the Dallas County Community College District.

I understand that this study is being used as dissertation research for Deborah Blackner, doctoral candidate in Applied Technology, Training and Development at the University of North Texas.

I give my consent to participate in the above study.

_______________________________________ _____________________

Name Date

For further information, contact:
Deborah Blackner (blackner1@msn.com)
154 West Saint Clair Drive
Irving, TX 75061
972-259-8922

This project has been reviewed and approved by the University of North Texas Institutional Review Board for the Protection of Human Subjects in Research (940) 565-3940.

APPENDIX B

PERMISSION TO USE INSTRUMENTS

UNIVERSITY OF

CONNECTICUT

THE COLLEGE OF LIBERAL ARTS AND SCIENCES
Department of Psychology

November 3, 1998

Deborah Blackner
154 West Saint Clair Drive
Irving, TX 75061

Dear Ms. Blackner:

You have my permission to reproduce and use the I-E Scale for your doctoral research.

Very truly Yours,

Julian B. Rotter

Julian B. Rotter
Professor of Psychology

An Equal Opportunity Employer

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Fax: 847.382.4510

http://www.excelcorp.com

Wednesday, December 9, 1998

Deborah Blackner
154 West Saint Clair Drive
Irving, TX 75061

Dear Deborah:

I was pleased to speak with Clif today about your dissertation study and the use of our assessment tool, the Learning Type Measure-LTM®. We will provide 300 of the sample research version of this instrument for your study. As indicated in your letter to Dr. Clif St. Germain, it is our understanding that we will also have the data sent to us as well as a copy of your dissertation study when it is completed. Dr. Clif St. Germain will be available to assist in your research as you deem appropriate.

We will send the research version of the LTM at a nominal charge of $25.00 to cover our administrative and shipping costs. Please send a check in the amount of $25.00 to Excel, Inc.

We grant you permission to use the LTM in your dissertation and to administer the research version of the LTM in your dissertation study. If this is agreeable to you, please sign this letter and return a copy to our office, attention: Susan Rossie.

We appreciate your interest in our work and look forward to working with you.

Sincerely,

Susan Rossie

Susan Rossie
Vice President
Excel, Inc.

Agreed to on ______________of 1998, by__________________.

D. BLACKNER

From: Carl Martray [mailto:Carl.Martray@usm.edu]
Sent: Tuesday, October 13, 1998 1:55 PM
To: D. Blackner
Subject: Re: Use of Abbreviated Mathematics Anxiety Rating Scale

Deborah,

Please feel free to use this instrument in your research. I wish I could be of more assistance but I recently changed positions and have no idea where related information may be placed. You may wish to contact Livingston Alexander at Kean University in New Jersey. He was recently appointed to the position of Provost at that institution. Good luck with your research!! -CRM

>On Mon,12 Oct 1998, D. Blackner wrote:
>
>Dear Dr. Martray,
>
>I am a doctoral candidate at the University of North Texas in Denton, Texas and am in
>the process of writing my dissertation proposal. My study proposes to attempt to
>predict the academic success of students enrolled in different teaching methodologies of
>developmental mathematics (in the community college setting) using mathematics
>anxiety as one of the predictive elements.
>
>In the October 1989 issue of "Measurement and Evaluation in Counseling and
>Development" you and Livingston Alexander presented a 25-item scale called the
>"Abbreviated Mathematics Anxiety Rating Scale." I hereby request your permission to
>use your scale as the instrument to measure mathematics anxiety during my dissertation
>study.
>
>To use this scale I assume I will take the 25 items from the article and administer them
>in order. If you have an assembled instrument with scoring guidelines I would
>appreciate it if you would let me know how to order it.
>
>Thank you so much for your time and I look forward to hearing from you.
>
>Sincerely,
>
>Deborah Blackner
>Doctoral Candidate at the University of North Texas
>Computer Information Systems Instructor, North Lake College, Irving, TX

D. Blackner

From: Livingston Alexander [mailto:lalexand@turbo.kean.edu]
Sent: Tuesday, October 27, 1998 7:54 AM
To: D. Blackner
Subject: Re: Use of Abbreviated Mathematics Anxiety Rating Scale

Hello Ms. Blackner,

Thanks for your inquiry and request to use the abbreviated scale. You may proceed to use it in your research. Simply combine the items as they appear in the article. You may list them in any order.

Good luck. Perhaps I'll read the results of your research someday.

Livingston Alexander

>On Thu,22 Oct 1998, D. Blackner wrote:
>
>Dear Dr. Alexander,
>
>I am a doctoral candidate at the University of North Texas in Denton, Texas and am in
>the process of writing my dissertation proposal. My study proposes to attempt to
>predict the academic success of students enrolled in different teaching methodologies of
>developmental mathematics (in the community college setting) using mathematics
>anxiety as one of the predictive elements.
>
>In the October 1989 issue of "Measurement and Evaluation in Counseling and
>Development" you and Carl Martray presented a 25-item scale called the >"Abbreviated
>Mathematics Anxiety Rating Scale." I hereby request your permission to >use your
>scale as the instrument to measure mathematics anxiety during my dissertation >study.
>
>I have already received permission from Dr. Martray, currently with the University of
>Southern Mississippi to use the instrument (I have included his reply at the bottom of
>this message). My major professor has asked that I also get your permission.
>
>To use this scale I assume I will take the 25 items from the article and administer them
>in order. If you have an assembled instrument with scoring guidelines I would
>appreciate it if you would let me know how to order it.
>
>Thank you so much for your time and I look forward to hearing from you.
>
>Sincerely,
>

>Deborah Blackner
>Doctoral Candidate at the University of North Texas
>Computer Information Systems Instructor, North Lake College, Irving, TX:
>
>
>
>>-----Original Message-----
>>From: Carl Martray [mailto:Carl.Martray@usm.edu]
>>Sent: Tuesday, October 13, 1998 1:55 PM
>>To: D. Blackner
>>Subject: Re: Use of Abbreviated Mathematics Anxiety Rating Scale
>>
>>Deborah,
>> Please feel free to use this instrument in your research. I wish I could be of more
>>assistance but I recently changed positions and have no idea where related information
>>may be placed. You may wish to contact Livingston Alexander at Kean University in
>>New Jersey. He was recently appointed to the position of Provost at that institution.
>>Good luck with your research!! -CRM

APPENDIX C

INSTRUMENTS

Rotter's Locus of Control

Last six digits of SSN or Name: ______________________________

Please read each statement carefully, then circle either "a" or "b" for each question. There are no right or wrong answers. Do not spend too much time on any single item, but please be sure to complete every item. Please answer every question independently—do not let a previous answer influence your choice. All answers will be kept confidential.

1. A. Children get into trouble because their parents punish them too much.
   B. The trouble with most children nowadays is that their parents are too easy with them.

2. A. Many of the unhappy things in people's lives are partly due to bad luck.
   B. People's misfortunes result from the mistakes they make.

3. A. One of the major reasons why we have wars is because people don't take enough interest in politics.
   B. There will always be wars, no matter how hard people try to prevent them.

4. A. In the long run people get the respect they deserve in this world.
   B. Unfortunately, an individual's worth often passes unrecognized no matter how hard he tries.

5. A. The idea that teachers are unfair to students is nonsense.
   B. Most students don't realize the extent to which their grades are influenced by accidental happenings.

6. A. Without the right breaks one cannot be an effective leader.
   B. Capable people who fail to become leaders have not taken advantage of their opportunities.

7. A. No matter how hard you try some people just don't like you.
   B. People who can't get others to like them don't understand how to get along.

8. A. Heredity plays the major role in determining one's personality.
   B. It is one's experiences in life which determine what they're like.

9. A. I have often found that what is going to happen will happen.
   B. It is one's experiences in life which determine what they're like.

10. A. In the case of the well prepared student, there is rarely if ever such a thing as an unfair test.
    B. Many times exam questions tend to be so unrelated to course work that studying is really useless.

11. A. Becoming a success is a matter of hard work, luck has little or nothing to do with it.
    B. Getting a good job depends mainly on being in the right place at the right time.

12. A. The average citizen can have an influence in government decisions.
    B. This world is run by the few people in power, and there is not much the little guy can do about it.

13. A. When I make plans, I am almost certain that I can make them work.
    B. It is not always wise to play too far ahead because many things turn out to be a matter of good or bad fortune anyhow.

14. A. There are certain people who are just no good.
    B. There is some good in everybody.

15. A. In my case getting what I want has little or nothing to do with luck.
    B. Many times we might just as well decide what to do by flipping a coin.

16. A. Who gets to be the boss often depends on who was lucky enough to be in the right place first.
    B. Getting people to do the right thing depends upon ability, luck has little or nothing to do with it.

17. A. As far as world affairs are concerned, most of us are the victims of forces we can neither understand nor control.
    B. By taking an active part in political and social affairs the people can control world events.

18. A. Most people don't realize the extent to which their lives are controlled by accidental happenings.
    B. There really is no such thing as luck.

19. A. One should always be willing to admit mistakes.
    B. It is usually best to cover up one's mistakes.

20. A. It is hard to know whether or not a person really likes you.
    B. How many friends you have depends on how nice a person you are.

21. A. In the long run the bad things that happen to us are balanced by the good ones.
    B. Most misfortunes are the result of lack of ability, ignorance, laziness, or all three.

22. A. With enough effort we can wipe out political corruption.
    B. It is difficult for people to have much control over the things politicians do in office.

23. A. Sometimes I can't understand how teachers arrive at the grades they give.
    B. There is a direct connection between how hard I study and the grades I get.

24. A. A good leader expects people to decide for themselves what they should do.
    B. A good leader makes it clear to everyone what their jobs are.

25. A. Many times I feel that I have little influence over the things that happen to me.
    B. It is impossible for me to believe that chance or luck plays an important role in my life.

26. A. People are lonely because they don't try to be friendly.
    B. There's not much use in trying too hard to please people, if they like you, they like you.

27. A. There is too much emphasis on athletics in high school.
    B. Team sports are an excellent way to build character.

28. A. What happens to me is my own doing.
    B. Sometimes I feel that I don't have enough control over the direction my life is taken.

29. A. Most of the time I can't understand why politicians behave the way they do.
    B. In the long run the people are responsible for bad government on a national as well as on a local level.

Abbreviated Mathematics Anxiety Rating Scale

Last Six Digits of SSN or Name: ______________________________

Each item on this instrument represents an area that may arouse anxiety. Please read each item carefully, then check the box that most closely matches your level of anxiety. There are no right or wrong answers. Do not spend too much time on any single item, but please be sure to complete every item. Please answer every question independently—do not let a previous answer influence your choice. All answers will be kept confidential.

Do you have anxiety when you are . .	Not at all	A little	A fair amount	Much	Very Much
1. Studying for a math test.	☐	☐	☐	☐	☐
2. Taking math section of college entrance exam.	☐	☐	☐	☐	☐
3. Taking an exam (quiz) in a math course.	☐	☐	☐	☐	☐
4. Taking an exam (final) in a math course.	☐	☐	☐	☐	☐
5. Picking up math textbook to begin working on a homework assignment.	☐	☐	☐	☐	☐
6. Being given homework assignments of many difficult problems that are due the next class meeting.	☐	☐	☐	☐	☐
7. Thinking about an upcoming math test 1 week before.	☐	☐	☐	☐	☐
8. Thinking about an upcoming math test 1 day before.	☐	☐	☐	☐	☐
9. Thinking about an upcoming math test 1 hour before.	☐	☐	☐	☐	☐
10. Realizing you have to take a certain number of math classes to fulfill requirement.	☐	☐	☐	☐	☐
11. Picking up math textbook to begin a difficult reading assignment.	☐	☐	☐	☐	☐
12. Receiving your final math grade in the mail.	☐	☐	☐	☐	☐

Do you have anxiety when you are . .

		Not at all	A little	A fair amount	Much	Very Much
13.	Opening a math or statistics book and seeing a page full of problems.	☐	☐	☐	☐	☐
14.	Getting ready to study for a math test.	☐	☐	☐	☐	☐
15.	Being given a "pop" quiz in a math class.	☐	☐	☐	☐	☐
16.	Reading a cash register receipt after your purchase.	☐	☐	☐	☐	☐
17.	Being given a set of numerical problems involving addition to solve on paper.	☐	☐	☐	☐	☐
18.	Being given a set of subtraction problems to solve.	☐	☐	☐	☐	☐
19.	Being given a set of multiplication problems to solve.	☐	☐	☐	☐	☐
20.	Being given a set of division problems to solve.	☐	☐	☐	☐	☐
21.	Buying a math textbook.	☐	☐	☐	☐	☐
22.	Watching a teacher work on an algebraic equation on the blackboard.	☐	☐	☐	☐	☐
23.	Signing up for a math course.	☐	☐	☐	☐	☐
24.	Listening to another student explain a math formula.	☐	☐	☐	☐	☐
25.	Walking into a math class	☐	☐	☐	☐	☐

Learning Type Measure

The 4MAT Learning Type Measure (LTM) is a copyrighted instrument and as such a copy is not included in this appendix. A copy of the LTM may be obtained directly from:

EXCEL, Inc.

Phone: 800-822-4MAT (4628)

http://www.excelcorp.com

Demographic Information

1. ***Name*** or ***last 6 digits of SSN:*** ____

2. ***Sex:*** M F

3. ***Age:*** _______

4. ***How long has it been since you took a mathematics course?***

   Less than one year One to two years Two to three years Over three years

5. ***Did you take the Developmental Math (DMAT) class previous to this one or did you test into this class directly?***

   Took the DMAT course that is before this one Tested directly into this class

6. ***How many times have you previously attempted but not successfully completed this same DMAT course?***

   Never One time Two times Three times Four or more times

7. ***In what instructional formats have you previously taken math classes?***

   Traditional on-campus lecture Computer-based in an on-campus lab

   Computer-based from home (distance education) Self paced

   Other: ____________________

8. ***Are you employed?***

   Yes No

9. ***If you are employed how many hours do you work per week?***

   Less than 10 10-19 20-29 30-39 40 or more

10. ***How are your college expenses paid for?*** (circle all that apply)

    Self Parents/Relatives Scholarship Other:

11. ***What is your ethnicity?***

    Hispanic African American Asian Caucasian Other:_____________

12. ***Is English your native language?*** Yes No

Request for Results

I would like a copy of my results on the following instruments at the end of the semester:

_____ Rotter's Locus of Control Scale

_____ Abbreviated Mathematics Anxiety Rating Scale

_____ The Learning Type Measure (LTM)

If you are in an on-campus section of Developmental Mathematics your results will be delivered to your instructor to distribute the week prior to or during your final exam.

If you are in a Distance Education section of Developmental Mathematics your results will be mailed to you during the week of final exam.

All information will be confidential. Your instructor will not be provided with anyone's individual information or answers.

Last six digits of SSN: ________________________________

Section Number: ________________________________

APPENDIX D

INSTRUMENT SCORING

SCORING ROTTER'S I-E LOCUS OF CONTROL SCALE

Participants choose one of two answers for each question. Each item matching the answer listed in the "Items to be Scored" column is given one point. Points are totaled and the participant receives an Internal or an External locus of control rating.

Items to be Scored:

2. A
3. B
4. B
5. B
6. A
7. A
9. A
10. A
11. B
12. B
13. B
15. B
16. A
17. A
18. A
20. A
21. A
22. B
23. A
25. A
26. B
28. B
29. A

Filler Items DO NOT SCORE:

1.
8.
14.
19.
24.
27.

Scores:

<=10	Internal
>=11	External

SCORING THE ABBREVIATED MATH ANXIETY RATING SCALE

Participants decide the level of anxiety associated with the item and report that decision by checking one of five boxes next to the item. Each item is converted to numerical form by assigning weights as follows:

Not at all	1
A little	2
A fair amount	3
Much	4
Very much	5

The sum of the item scores provides the total score for the instrument, which can range from 25 to 125. This score is then divided by the number of items on the test (25) to get the mean score for the instrument.

In addition, the first 15 questions measure the math text anxiety dimension of mathematics anxiety. Questions 16 through 20 measure numerical task anxiety, and items 21 through 25 measure math course anxiety. The mean score for these three different dimensions of mathematics anxiety can be examined individually to determine if one area causes more problems for students than others.

Scoring the Learning Type Measure

The 4MAT Learning Type Measure (LTM) is a copyrighted instrument and as such a copy of the scoring guidelines is not included in this appendix. A copy of the scoring guidelines for the LTM may be obtained directly from:

EXCEL, Inc.

Phone: 800-822-4MAT (4628)

http://www.excelcorp.com

APPENDIX E

INSTITUTIONAL LETTERS OF APPROVAL

North Lake College

November 16, 1998

Deborah Blackner
154 W. St. Clair Drive
Irving, TX 75061

Dear Ms. Blackner:

I would like to formally express my support for you to conduct your doctoral dissertation project, "Prediction of Community College Students' Success in Developmental Math with Traditional Classroom, Computer-Based On-Campus and Computer Based at a Distance Instruction using Locus of Control, Math Anxiety and Learning Style", at North Lake College with North Lake College students.

It is understood that student participation will be voluntary, and that all individual student information will be kept confidential and reported only in aggregate form. We would also ask that, upon the conclusion of the study, that all individual student information be destroyed.

We are excited about the potential of this project to provide important information that we can use to improve student success at North Lake College. Best of luck on your project.

Cordially,

David England
President

5001 N. MacArthur Blvd.
Irving, Texas 75038-3899
FAX (972) 273-3014

President:
David C. England, Ed.D.
972-273-3010

Vice President for Academic and Student Affairs:
Angie S. Runnels, Ph.D.
972-273-3590

Vice President of Administrative Services:
John T. Tuohy, M.P.A.
972-273-3390

NORTH LAKE COLLEGE OF THE DALLAS COUNTY COMMUNITY COLLEGE DISTRICT

University of North Texas
Sponsored Projects Administration

December 14, 1998

Deborah Blackner
154 W. St. Clair Drive
Irving, TX 75061

Re: Human Subjects Application No. 98-250

Dear Ms. Blackner:

As permitted by federal law and regulations governing the use of human subjects in research projects (45 CFR 46), I have conducted an expedited review of your proposed project titled "Predication of Community College Students' Success in Developmental Math With Traditional Classroom Computer-Based On-Campus And Computer-Based at A Distance Instruction Using Locus of Control, Math Anxiety and Learning Style." The risks inherent in this research are minimal, and the potential benefits to the subjects outweigh those risks. The submitted protocol and informed consent form is hereby approved for use of human subjects on this project.

The UNT IRB must re-review this project prior to any modifications you make in the approved project. Please contact me if you wish to make such changes or need additional information.

If you have any questions, please contact me.

Sincerely,

Sandra L. Terrell

Sandra L. Terrell, Chair
Institutional Review Board

ST:sb

P.O. Box 305250 • Denton, Texas 76203-5250
(940) 565-3940 • Fax (940) 565-4277 • TDD (800) 735-2989
e-mail: lane@abn.unt.edu

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